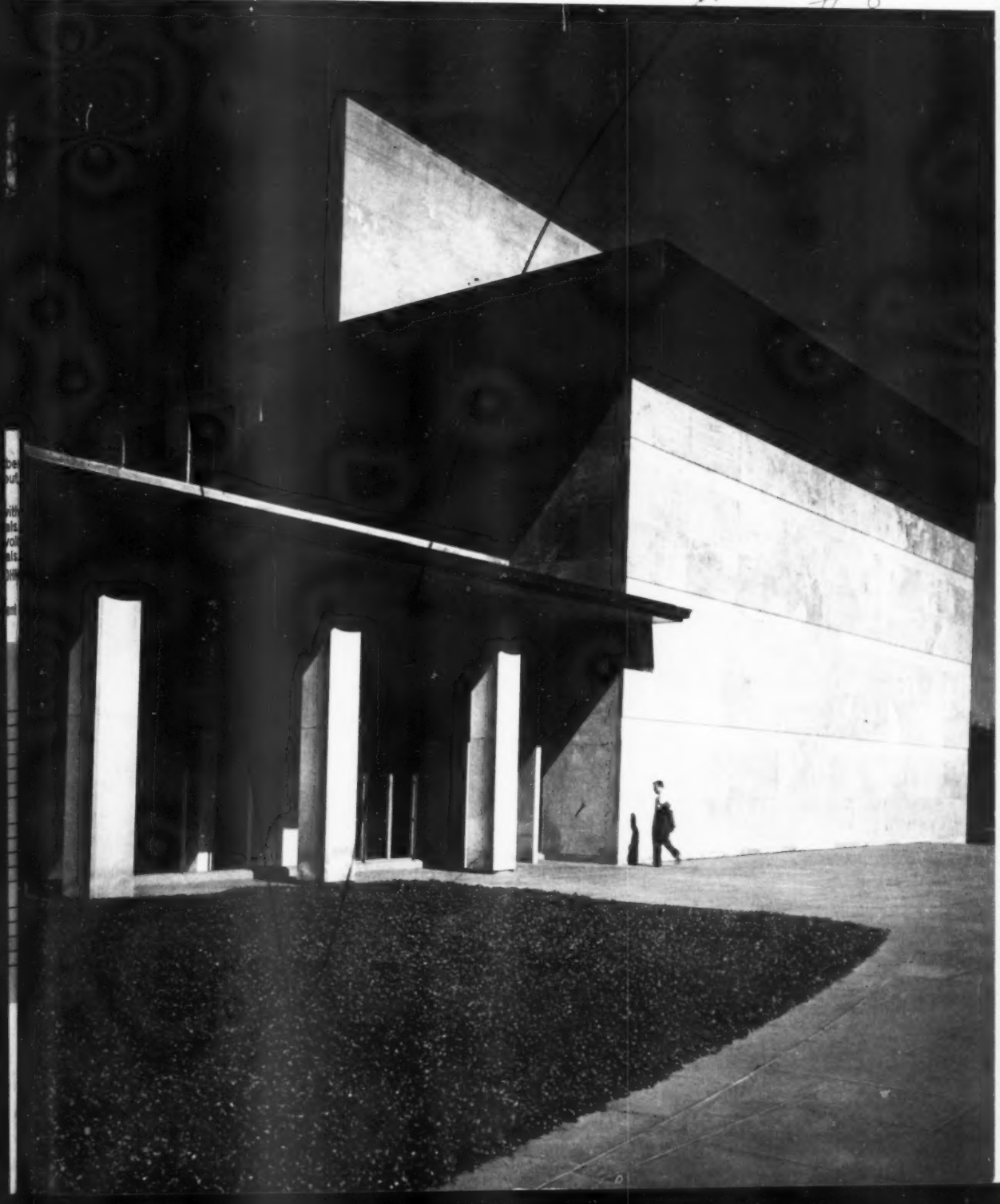
TECHNOLOGY DEPT.

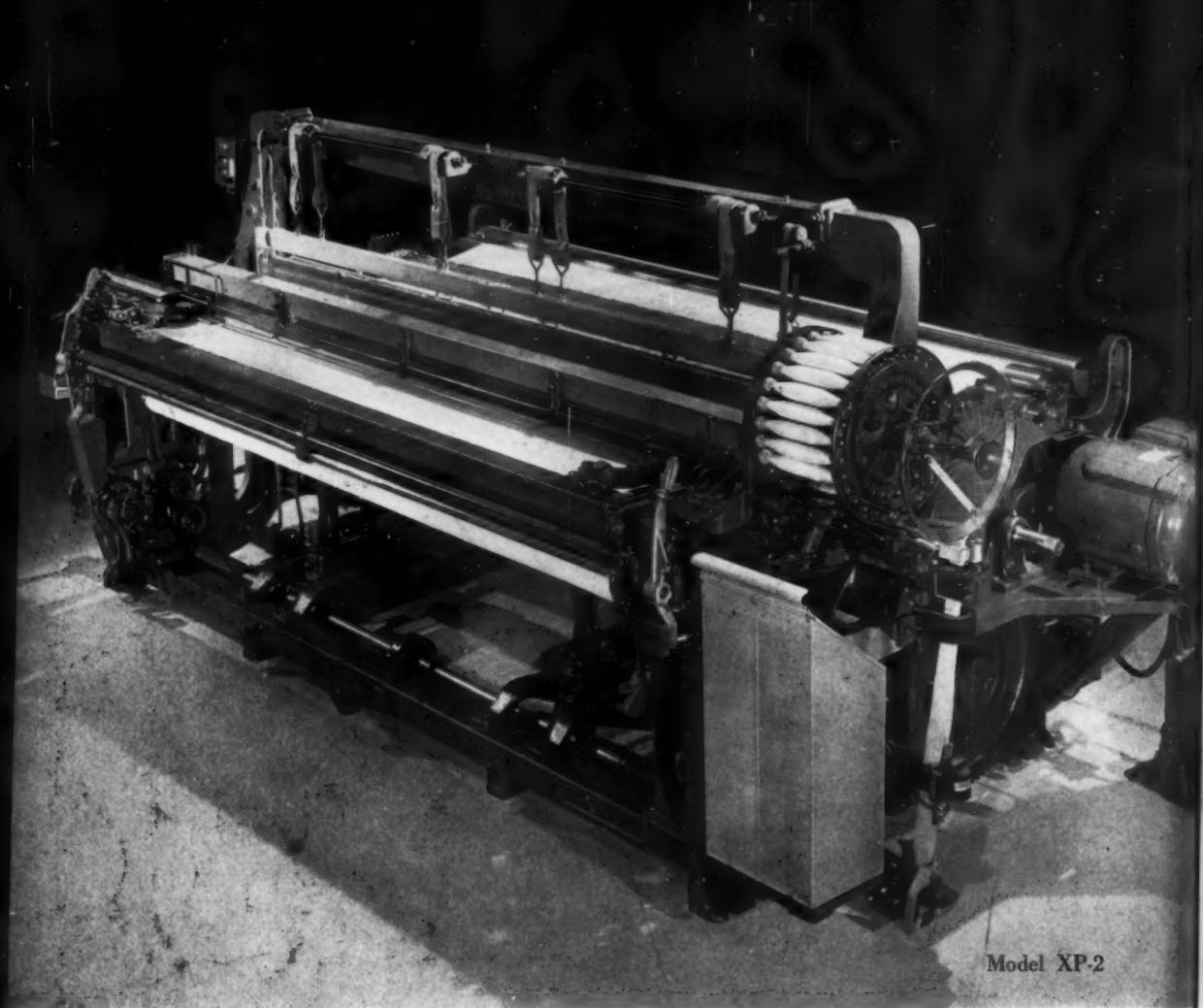
TECHNOLOGY REVIEW

PUBLIC LIBRARY
JUN 10 1957
DETROIT

June 1957

v.59 #8





Model XP-2

Increase Wide Sheeting Production . . . with the new XP-2

New constructions found necessary for higher speeds in other models are now available *for the first time* in a wide sheeting loom.

The Draper XP-2 is equipped with a conventional type Pick Motion, simplified Power Transmitter, Bartlett Let-Off, Worm Take-Up, Easy Shipper and Positive Brake.

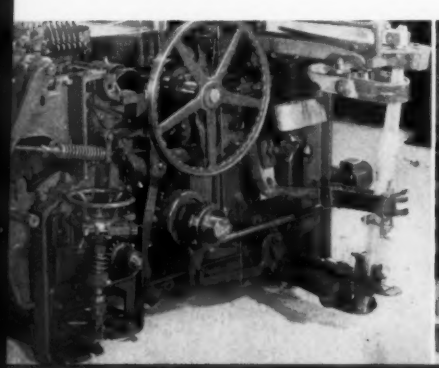
These adaptations mean increased production, greater loom versatility, less downtime and easier loom operation.

Engineered for high speed and efficient performance the Draper XP-2 *offers better profit margins.*

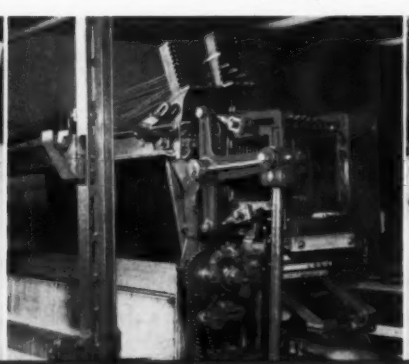
DRAPER CORPORATION

Hopedale, Mass.

Atlanta, Ga. *Greensboro, N. C.* *Spartanburg, S. C.*



Automatic Bartlett Let-Off

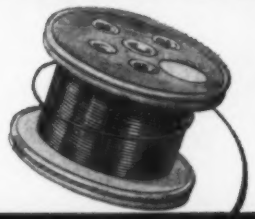


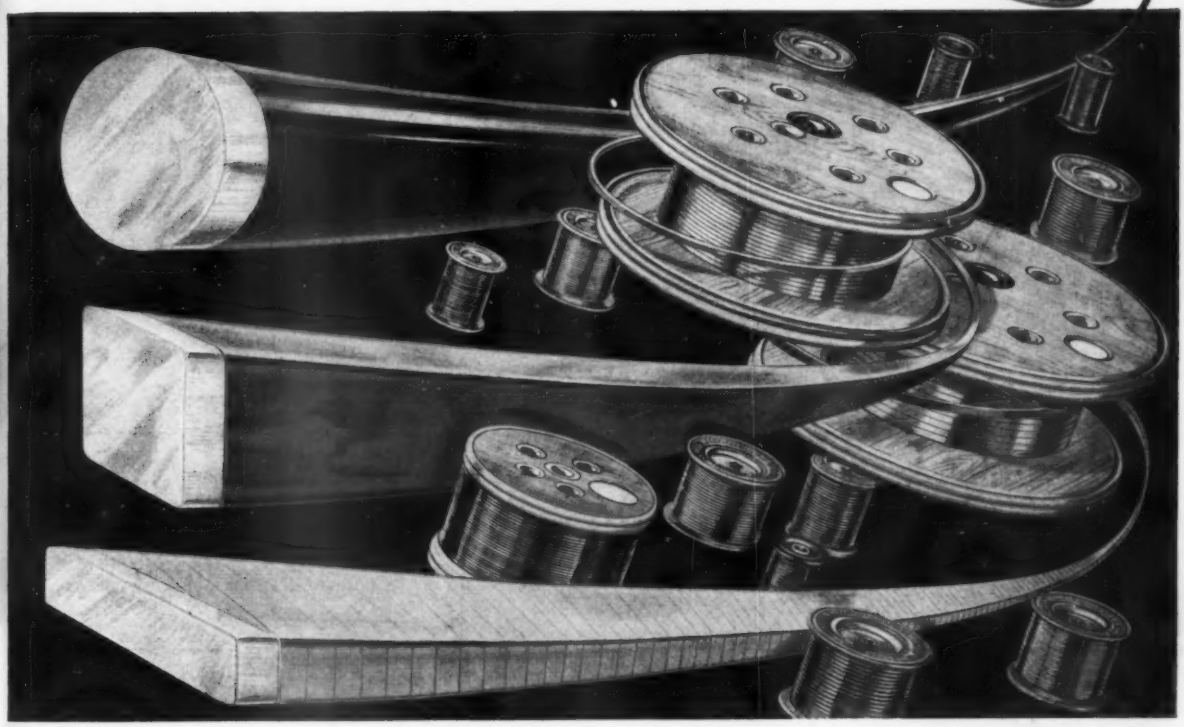
Available with 16 Harness Dobby

Draper-Ossit Drive

IF MAGNET WIRE IS YOUR PROBLEM

. . . Phelps Dodge has
the Quickest, Easiest Answer!





▶ *Most Complete and Up-to-Date Line of Magnet Wire in the Industry.*

▶ *Every Type of Insulation to Meet Design Requirements.*

Enamel • Formvar • Sodereze® • Bondeze® • Thermaleze® • Grip-eze®
Silicone Enamel • Daglas® • Daglas® Silicone • Paper • Cotton • Multiple Combinations

▶ *Available in all Sizes and Shapes—Round, Square, Rectangular . . .*

Over 400 Different Types!

First for Lasting Quality —from Mine to Market!

PHELPS DODGE COPPER PRODUCTS CORPORATION

INCA MANUFACTURING DIVISION

FORT WAYNE, INDIANA

THE TECHNOLOGY REVIEW, June, 1957, Vol. LIX, No. 8. Published monthly from November to July inclusive at Emmett Street, Bristol, Conn. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription, $4.00: Canadian and Foreign subscription, $4.50. Entered as second-class matter December 23, 1949, at the Post Office, at Bristol, Conn., under the Act of March 3, 1879.

WHICH OF THESE JOBS CAN YOU FILL?

	COMPUTER AND CONTROL ENGINEERING	MISSILE GUIDANCE ENGINEERING

ELECTRICAL AND ELECTRONIC ENGINEERS with 2 or more years experience in:	• Gyro Development
	• Servo-mechanisms and Feedback Systems
	• Analog Computers
	• Military Specifications
	• Electronic Circuitry
	• Magnetic and Transistor Amplifiers
	• Network Design
	• Inverters
	• AC and DC Servo Motors
	• Electronic Research
	• Fire Control Systems
	• Microwaves and Radar
	  ◦ Antennas
	  ◦ Beacons
	  ◦ Receivers
	  ◦ Transmitters
	  ◦ Pulse Circuits
	• Digital Computers and Data Processing
		• Gyro Development
		• Servo-mechanisms and Feedback Systems
		• Analog Computers
		• Military Specifications
		• Electronic Circuitry
		• Magnetic and Transistor Amplifiers
		• Network Design
		• Inverters
		• AC and DC Servo Motors
		• Electronic Research
		• Missile Control Systems

MECHANICAL ENGINEERS with 2 or more years experience in:	• Inertial Guidance Systems • Gyro Development • Military Specifications • Servo-mechanisms • Product Design and Packaging of Electro-Mechanical Devices • Fire Control Systems	• Inertial Guidance Systems • Gyro Development • Military Specifications • Servo-mechanisms • Product Design and Packaging of Electro-Mechanical Devices
NUCLEAR ENGINEERS AND PHYSICISTS with experience in:	**NUCLEAR REACTORS** • Control • Metallurgy • Physics • Instrumentation	

Do you dare tackle tough problems? At Ford Instrument Co., finding the answer to problems is the engineer's prime responsibility. As a result, the engineer who meets this challenge receives the professional and financial rewards his work merits. Our qualifications are high, and we want to be sure you can match the high standards of our present engineering staff. Our projects are too important and too complicated to trust to most engineers. What will you do at FICo? That depends on your specific abilities and experience. For details about the challenge, environment, and opportunity at FICo, write Philip F. McCaffrey at below address.

FICo

FORD INSTRUMENT CO.

DIVISION OF SPERRY RAND CORPORATION

31-10 Thomson Avenue • Long Island City 1, N. Y.

NEED A KING-SIZE BASKETBALL?

This one is a spherical reactor operating at 650 psi and 850°. Graver ingenuity and skill fabricated the carbon steel outer shell, lined it first with 6″ of gunite, then with Type 321 stainless steel interior and fittings. For precision-built pressure vessels in alloys or carbon steel, call on Graver.

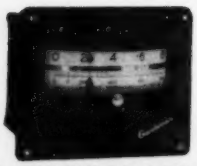
ALLOY DIVISION

1857-1957 GRAVER

A CENTURY OF CRAFTSMANSHIP IN STEELS AND ALLOYS

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA • NEW YORK • PHILADELPHIA • EDGE MOOR, DELAWARE
PITTSBURGH • DETROIT • CHICAGO • TULSA • SAND SPRINGS, OKLAHOMA
HOUSTON • LOS ANGELES • FONTANA, CALIFORNIA • SAN FRANCISCO



WHAT DOES

BETTER TEMPERATURE CONTROL

MEAN TO YOU?

It might mean greater accuracy . . . more consistent reliability . . . simplicity . . . elimination of vacuum tubes or possibly compactness or low cost. Another way, it could mean greater volume of production . . . improved quality . . . lower unit-costs. *Any* way, in many different fields, it means instruments by WEST.

Here and abroad we produce a wide selection of controllers, indicators and recorders for temperature and other variables, as well as complete systems and accessories. Our men in scores of cities offer qualified counsel. Write for Bulletin COM.

WEST *Instrument*
CORPORATION
SALES OFFICES IN PRINCIPAL CITIES

4355C W. MONTROSE, CHICAGO 41, ILL.

British Plant: WEST INSTRUMENT LTD.
52 Regent St., Brighton 1, Sussex
Represented in Canada by Upton, Bradeen & James

Standard Quality sets Quality Standards

The day-in, day-out excellence, the quality which is standard in every Curtis Universal Joint, has made the Curtis Joint the quality standard of the industry.

Each Curtis Universal Joint component is made from specially selected steel, individually heat-treated for a specific purpose. This accounts for the inherent balance, long life and dependable performance of Curtis Universal Joints.

CURTIS UNIVERSAL JOINTS

- 14 sizes always in stock, ¾" to 4" O.D.
- Fewer parts, simpler construction
- Complete equipment for government tests

Our catalog torque and load ratings are substantiated by constant tests. You can depend on them.

Not sold through distributors. Write direct for free engineering data and price list.

CURTIS
Trade Mark
UNIVERSAL JOINT CO., INC.
8 BIRNIE AVE., SPRINGFIELD, MASS.
As near to you as your telephone

THE TABULAR VIEW

Management Convocation. – The summary report of the Fifth Anniversary Convocation of the School of Industrial Management (page 403) has been prepared by The Review's editor with the assistance of members of the School of Industrial Management and the M.I.T. Photographic Service. It may also be well to remind Review readers that "Individuals Noteworthy" and "Twenty-five Years Ago This Month," which have been features of the Trend of Affairs in this volume, are the work of H. E. LOBDELL, '17, publisher of The Review.

Tomorrow's Managers. – Banquet address of the convocation of the School of Industrial Management, on April 9, was given by CLEO F. CRAIG, chairman of American Telephone and Telegraph Company's Board of Directors, which The Review is happy to present on page 409. Mr. Craig's telephone career began in 1913 upon his graduation from the University of Missouri with a degree in electrical engineering. When he was graduated at the age of 20 he was a member of Tau Beta Pi and Eta Kappa Nu. He progressed through the Bell System becoming District Plant Superintendent in 1920, Plant Accountant in 1922, Special Representative in the Vice-president's Office in 1927, General Manager of Long Lines Department in 1933, Vice-president in charge of Long Lines in 1940, Vice-president in charge of Personnel in 1941, Vice-president of Operation and Engineering Department in 1948, and President in 1951. He is a director or trustee of several corporations and public institutions. In 1952 he received the honorary LL.D. degree from his alma mater.

Financial Forces. – Luncheon speaker, at the April 9 convocation of the School of Industrial Management, was ELI SHAPIRO whose address appears on page 412 of this issue. Dr. Shapiro is professor of finance and associate dean of the School of Industrial Management. He received the B.A. degree from Brooklyn College (1936), and the M.A. and Ph.D. degrees from Columbia University in 1937 and 1945. Further details about him appear in the Institute Gazette section of The Review for January, 1955.

Systems Technology. – JAY W. FORRESTER, '45 – whose biography appeared in detail in the Trend of Affairs section of The Review for November, 1956 – is the author of "Systems Technology and Industrial Dynamics" (page 417) presented at the April 9 convocation of the School of Industrial Management. The University of Nebraska awarded him the B.Sc. degree "with high distinction" in 1939 and the honorary D.Eng. in 1954. He received the S.M. degree from M.I.T. in 1945. Since last fall, Dr. Forrester has been professor of industrial management.

Life Sciences. – To those persons who still think of M.I.T. as primarily a school of engineering, "Life Sci-

(*Concluded on page 390*)

. . . pipes or purses

. . . cleats or clay pigeons

. . . galoshes or golf balls

Better Products begin with CABOT!

Whether they're smoked, shot at, or whacked with a 2-iron, products containing Cabot raw materials contain a precious plus.

The plus comes from 75 years of Cabot know-how . . . three quarters of a century spent in intimate association with industry, its markets, and its problems. From this rich storehouse of experience . . . from the wide variety of Cabot raw materials . . . may come the product plus you've been looking for.

Whatever you make, it costs nothing to find out if Cabot can put a plus in your product. Why not put a call in . . . today?

WHICH OF THESE CABOT MATERIALS CAN HELP YOUR PRODUCT?

CABOT CARBON BLACKS . . . *more than 45 different grades of channel, furnace and thermal blacks for use by the rubber, printing ink, paint, varnish, lacquer, enamel, plastics, paper, phonograph record, battery and other industries.*

WOLLASTONITE . . . *as a paint pigment, this white, uniform calcium metasilicate, has more desirable properties than other extenders used singly or in combination. Excellent for ALL types of paint, and for the quality improvement of wall tile and semi-vitreous ceramics.*

CAB-O-SIL® . . . *this unique colloidal silica, in extremely small quantities, greatly improves large numbers of products. The best flow control agent available, it's especially remarkable for its unusual combination of properties. Used for rubber, paint, varnish, printing ink, plastics, lubricants, cosmetics, many other products.*

CABFLEX® PLASTICS CHEMICALS . . . *a complete range of plasticizers developed for the specific improvement of rubber and vinyl plastic products.*

PT® PINE TAR PRODUCTS . . . *these versatile quality controlled materials improve the performance of a wide variety of products, including: rubber, paint, cordage, oakum and insecticides.*

For complete information, phone or write:

GODFREY L. CABOT, INC.
77 FRANKLIN ST., BOSTON 10, MASSACHUSETTS
Phone: Liberty 2-7300

CABOT®

N. B.

Write for the folder describing activities of The Lincoln Laboratory:

HEAVY RADARS
MEMORY DEVICES
TRANSISTORIZED
DIGITAL COMPUTERS
SCATTER COMMUNICATIONS
SOLID STATE
AEW (air-borne early warning)
SAGE (semi-automatic ground environment)

. . . and others which are integral parts of the nation's air defense system.

Our need for qualified PHYSICISTS, ENGINEERS and MATHEMATICIANS is urgent.

RESEARCH AND DEVELOPMENT

MIT LINCOLN LABORATORY

Box 28, Lexington 73, Massachusetts

GEARS

Made to Your Specifications

You and we can form a team—you to draw up the specifications; we to make the gears—that will be profitable to both of us. Gears of all types, all sizes, all materials. Design-engineering service available.

Custom Gears Exclusively

DIEFENDORF GEAR CORPORATION

Syracuse 1, N. Y.

DIEFENDORF GEARS

THE TABULAR VIEW

(*Concluded from page 388*)

ences – M.I.T. Style" (page 423) may come as an eye opener. This survey of 117 M.I.T. projects in the life sciences was written by IRWIN W. SIZER, a member of the Institute's staff since 1935, and recently named head of the Department of Biology. He received the A.B. degree from Brown University in 1931 and the Ph.D. from Rutgers in 1935. Other biographical information on Dr. Sizer appeared in the Trend of Affairs section of The Review for March, 1957.

MAIL RETURNS

PROPER CREDIT

FROM PROFESSOR GORDON S. BROWN, '31:

I am very much pleased to note your insertion of three references (page 372) on the general topic of "Automation" at the conclusion of my article on Automation in the May, 1957, issue of The Review. I wish to point out, however, that I have been given more credit than I am entitled to receive for the authorship of two of the references.

The article on "Control Systems," published in the *Scientific American*, was prepared jointly with my colleague Dr. Donald P. Campbell as co-author. (Donald Pierce Campbell, a member of the Class of 1943, died on January 15, 1957.) This article may also be found in the volume entitled *Automatic Control* of the *Scientific American Books* published by Simon and Schuster in 1956. The article referenced in *American Machinist* was not written by me at all. The authors were William Stocker, Jr., C. D. Emerson, and the staff of the Servomechanisms Laboratory.

I would be grateful if you would bring these corrections to the attention of the readers of The Review.

Head, M.I.T. Department of Electrical Engineering, Cambridge, Mass.

R. C. Williams & Co., Inc.
Cass Gilbert, Inc., Architect

Insures Quality · Saves Money

We do a large part of each building operation with our own forces, subletting only specialty work. That's one reason why we can guarantee quality and speed at very reasonable cost.

W. J. BARNEY CORPORATION
Founded 1917
INDUSTRIAL CONSTRUCTION
101 Park Avenue, New York
Alfred T. Glassett, '20, President

Human history is in essence a history of ideas*

*H. G. Wells 1895

Thomas Alva Edison

Harnessing electrical energy was his fixed idea At 27 he had invented the world's first incandescent lamp. Edison, a practical genius, inspired his team with enthusiasm. In the ensuing 57 years of his life he led them to find more ways to make electricity produce sound, light, motive power and heat —with more ideas than any other man of his time.

The Kerite Company was established when Edison was but eight years old. By the time his inventions were ready to add to America's prosperity, Kerite craftsmen had acquired more than a generation of cable-making "know-how." The newly formed utility and railroad companies of the 1870's relied then, as do their successors today, on the unfailing service and long life of Kerite cable.

As power loads increase year by year, the inherited integrity and skill of today's Kerite craftsmen insure that the demands of far-sighted utility, industrial and railroad engineers will be amply fulfilled in the years ahead.

The value and service life of a product can be no greater than the integrity and craftsmanship of its maker.

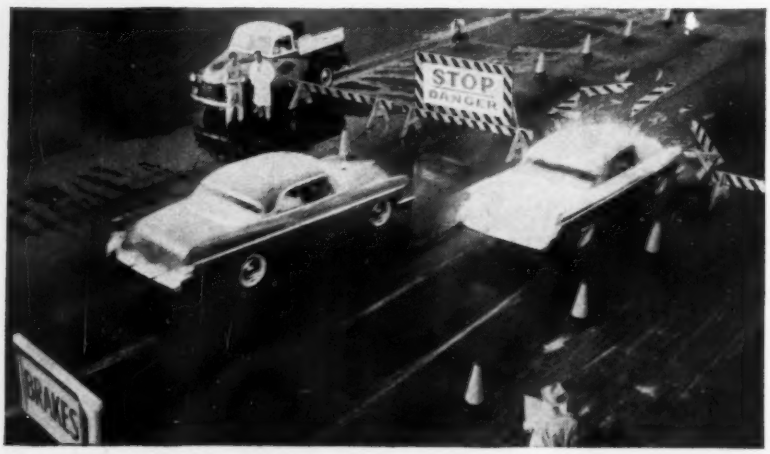
KERITE CABLE

Founded 1854

THE KERITE COMPANY—30 Church St., New York 7, N. Y.
Offices also at 122 S. Michigan Ave., Chicago; 582 Market St., San Francisco;
3901 San Fernando Rd., Glendale 4, Calif.; 31 St. James Ave., Boston;
4101 San Jacinto, Houston 4, Texas; 1010 Euclid Avenue, Cleveland 17, Ohio;
29 West Lancaster Avenue, Ardmore, Pa.

Proved able to stand incredible abuse...
GOODYEAR'S NEW 3-T NYLON CORD TIRES!

STRONGER ON THE INSIDE!
A mounted jackhammer—the same kind that's used to break concrete—pounded this Goodyear 3-T Nylon tire for 34 hours, delivering over two million blows—without breaking a single cord. Proof of the miracle strength you get in Goodyear's 3-T Nylon Cord.



SAFER ON THE OUTSIDE!
In this wet-road test, two cars rushed toward the barriers at the same speed—braked at the same instant. The light car, with ordinary-type tires, hit the barricade. But Goodyear's Twin-Grip tread with 8640 biting edges brought the dark car to a safe stop!

There's a *big difference* in nylon cord. 3-T Nylon Cord is different because it's triple-tempered by an exclusive Goodyear process. Better because triple-tempering makes it triple-tough!

IT takes nylon cord to stand up best to the punishing demands of modern driving.

But, unless properly pre-conditioned, nylon stretches under tension. To control this stretch Goodyear developed an exclusive process involving precisely controlled Tension, Temperature and Time.

The result: triple-tempered 3-T Nylon Cord—stabilized at its point of maximum strength and resiliency. This makes it more durable and blowout resistant.

And Goodyear's 3-T Nylon Cord tire, with its new Twin-Grip tread design, has two fully independent treads to make it your best bet against all kinds of road hazards.

What's more, Goodyear gives you a Lifetime Guarantee. See your dealer for details—this week for sure. Goodyear, Akron 16, Ohio.

MORE PEOPLE RIDE ON GOODYEAR TIRES THAN ON ANY OTHER KIND!

Watch "The Goodyear Playhouse" on TV Sunday—9-10 P. M., E. D. T.

NEW 3-T NYLON CUSTOM SUPER-CUSHION

GOODYEAR

Look for this nearby Goodyear dealer sign for better tire values . . . better tire care . . . convenient credit terms.

Super-Cushion, T. M., The Goodyear Tire & Rubber Company, Akron, Ohio

Publishe
seventh
Annual
Publishe
Presiden
John J. W

JUNE,

Paul L. Rittenhouse

Pont du Gard, Avignon

Technology Review

TITLE REGISTERED, U. S. PATENT OFFICE

Edited at the Massachusetts Institute of Technology

VOL. 59, NO. 8 JUNE, 1957

Contents

ENTRANCE TO EXHIBITION HALL, HAYDEN LIBRARY ..... Front Cover
Photograph by M.I.T. Photographic Service

CONVOCATION MONTAGE ..... Frontispiece 394
Medley of persons and events of the School of Industrial Management Convocation

SCHOOL OF INDUSTRIAL MANAGEMENT HAS CONVOCATON — A Technology Review Report 403
A record of events in celebration of the fifth anniversary of M.I.T.'s newest school

TOMORROW'S MANAGERS ..... By Cleo F. Craig 409
Unless the rewards, challenges, and opportunities are such as to encourage men to grow, we shall level our motives and abilities in a downward direction

FINANCIAL FORCES IN INDUSTRIAL GROWTH ..... By Eli Shapiro 412
Improved understanding of our financial system is needed to achieve higher standards of living, national security, economic growth, and social capital formation without running the risks of inflation or depression

SYSTEMS TECHNOLOGY AND INDUSTRIAL DYNAMICS By Jay W. Forrester 417
Industrial dynamics combines basic flow patterns of information, money, materials, and man power to permit over-all systems approach to industrial organization

LIFE SCIENCES — M.I.T. STYLE ..... By Irwin W. Sizer 423
Unexcelled resources are tapped to support 117 research projects in the life sciences

THE TABULAR VIEW 388
Contributors and contributions to this issue

MAIL RETURNS 390
Letters from Review Readers

THE TREND OF AFFAIRS 395
Relating to the Massachusetts Institute of Technology

EDITOR: B. Dudley

BUSINESS MANAGER: R. T. Jope

CIRCULATION MANAGER: D. P. Severance

EDITORIAL ASSOCIATES: Paul Cohen, J. R. Killian, Jr., F. W. Nordsiek, J. J. Rowlands

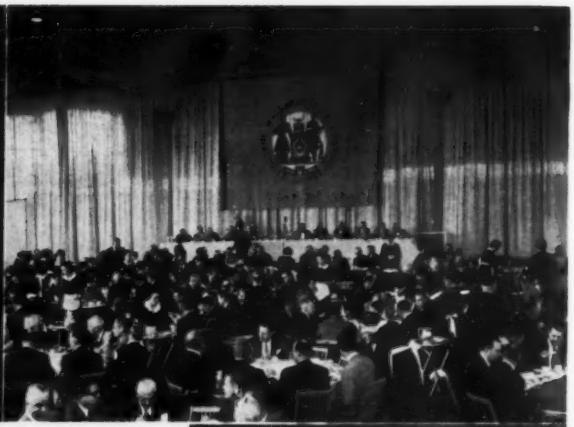
EDITORIAL STAFF: Ruth King

BUSINESS STAFF: Eileen E. Klimowicz, Madeline R. McCormick

PUBLISHER: H. E. Lobdell

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 60 cents a copy. Annual subscription, $4.00; Canadian and foreign subscription, $4.50. Published for the Alumni Association of the M.I.T.; Theodore T. Miller, President; H. E. Lobdell, Executive Vice-president; Saxton W. Fletcher, John J. Wilson, Vice-presidents; Donald P. Severance, Secretary-Treasurer.

Published at Hildreth Press, Inc., Bristol, Conn. Editorial Office, Room 1-281, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the Post Office at Bristol, Conn. Copyrighted, 1957, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect change of address, for which both old and new addresses should be given.



Anniversary Convocation

In celebration of five successful years of operation, the Institute's School of Industrial Management held a convocation in Cambridge on Tuesday, April 9, at which these informal scenes were caught by the M.I.T. Photo Service. In clockwise order, beginning at upper left corner are: (1) Guests registering in lobby of Kresge Auditorium; (2) catered luncheon in Rockwell Cage with speakers' table shown under M.I.T. banner; (3) E. P. Brooks, '17, Dean, School of Industrial Management, and Jay W. Forrester, '45, Professor of Industrial Management, both of whom spoke at the morning session; (4) Eli Shapiro, Associate Dean, School of Industrial Management and luncheon speaker, with J. A. Stratton, '23, M.I.T. Chancellor; (5) guests arriving for the banquet in the Hotel Sheraton Plaza in Boston; (6) President Killian at the banquet, flanked by Alfred P. Sloan, Jr., '95 (left), and Cleo F. Craig, who gave the principal banquet address; (7) members of panel group who discussed role of corporate director (left to right): Sidney L. Weinberg, Eugene V. Rostow, Lyman Bryson, David A. Shepard, '26, and Vannevar Bush, '16; and (8) Douglas M. McGregor, Professor of Industrial Management, a speaker at the morning session.

The Technology Review

VOL. 59, NO. 8 JUNE, 1957

The Trend of Affairs

The Voters Speak

■ Perhaps the elective process is the best possible demonstration of the workings of a truly democratic organization. Of the Institute's Alumni body, approximately 3,000 participated in the election of new officers to head the M.I.T. Alumni Association for the year beginning July 1, 1957.

Gilbert M. Roddy, '31, Vice-president of the Boston Manufacturers Mutual Insurance Company and Mutual Boiler and Machinery Insurance Company, was elected president of the Association for the 1957–1958 year. D. Reid Weedon, Jr., '41, Vice-president of Arthur D. Little, Inc., was elected to serve a two-year term as vice-president of the Association.

Raymond A. St.Laurent, '21, and William L. Taggart, Jr., '27, were each elected to serve two-year terms on the Executive Committee of the Association. Mr. St.Laurent is vice-president of Rogers Corporation, Rogers, Conn., and Mr. Taggart is executive vice-president of Dewey and Almy Chemical Company (Division of W. R. Grace and Company), Cambridge.

Alumni term members to serve on the M.I.T. Corporation for a five-year term were: Charles A. Chayne, '19, Vice-president in charge of Engineering Staff, General Motors Corporation; Theodore T. Miller, '22, President of Polymer Chemicals Division of W. R. Grace and Company (who is now serving as President of the Alumni Association for the fiscal year 1956–1957); and Clarence L. A. Wynd, '27, Vice-president of the Eastman Kodak Company, and assistant general manager of the Kodak Park Works in Rochester, N.Y.

Three-year terms, to serve on the National Nominating Committee, went to: Bissell Alderman, '35 (District 3); Henry Avery, '41 (District 6); and Edmund D. Ayres, '22 (District 7). Mr. Alderman is partner in the firm of Alderman and MacNeish, architects and engineers of West Springfield, Mass. He served as an officer of the M.I.T. Club of the Connecticut Valley during 1949–1951. Mr. Avery is general manager of the Industrial Chemicals Division, Pittsburgh Coke and Chemical Company. In 1953–1954 he was vice-president and in 1954–1955 president of the M.I.T. Club of Western Pennsylvania. Mr. Avery also serves as Assistant Secretary for his Class. Mr. Ayres is professor of electrical engineering at the Ohio State University in Columbus. He is also a member of the M.I.T. Club of Central Ohio (Columbus).

The 12 Alumni elected to represent their classes on the Alumni Council for five-year terms, beginning July 1, 1957, are: Edward S. Chapin, '98, Ichabod F. Atwood, '03, Joseph W. Wattles, 3d, '08, R. Charles Thompson, '13, Max Seltzer, '18, George A. Johnson, '23, Arthur A. Nichols, '28, Lincoln W. Ryder, '33, Albert O. Wilson, Jr., '38, Robert W. Anderson, '43, Richard H. Harris, '48, and Marion C. Manderson, '53.

Gilbert M. Roddy, '31 . . .
President of the Alumni Association for the year beginning July 1, 1957

M.I.T. Photo

Shell Christened for Cochrane

■ In christening ceremonies at the M.I.T. Boat House on Saturday, April 27, an eight-oared shell was named in honor of Admiral Edward L. Cochrane, '20, who will become special assistant to James R. Killian, Jr., '26, President, upon his retirement on July 1. As Vice-president for Industrial and Governmental Relations since 1954, Admiral Cochrane has been concerned with the whole range of M.I.T. responsibilities to industry and government. He has had the major responsibility for co-ordinating and giving administrative support to all of the Institute's sponsored research, including Lincoln Laboratory and the Instrumentation Laboratory.

Following his retirement from the Navy in 1947, where he had been chief of the Bureau of Ships, Admiral Cochrane served as head of the Department of Naval Architecture and for two years (1952–1954) was dean of engineering at the Institute.

Shown in the photograph above with Admiral Cochrane are: Michael A. Drew, '59 (left), lightweight crew manager; and Robert W. Root, '57, varsity lightweight crew captain.

The christening was done by Mrs. Cochrane. The bow of the light shell was suitably protected as a bottle of Charles River water was broken over it.

Alumni Day, 1957

■ The program for Monday, June 10, will retain many of the traditional features which have endeared Alumni Day to former M.I.T. students. There will be a morning conference, President Killian's luncheon in Du Pont Court, and the Alumni Banquet in the evening. But dedicatory services of the new Karl Taylor Compton Laboratories, with tours of these laboratories, as well as of the new nuclear reactor (under construction) and the Computer Center, will add new features to this year's program.

Julius A. Stratton, '23, Chancellor of M.I.T., will preside at the morning symposium on "Today's Science – Tomorrow's Promise." Speakers will be James B. Fisk, '31, Executive Vice-president of the Bell Telephone Laboratories, and Jerrold R. Zacharias, Professor of Physics at the Institute. Dr. Fisk will describe many of the latest research programs in the physical sciences, particularly those in electronics and communications. Dr. Zacharias will tell how scientists are at work on an educational program aimed to promote a better understanding of science by laymen and to develop more significant programs of instruction in physics at the high school level.

At luncheon, in Du Pont Court, Dr. Killian will describe developments at M.I.T., the problems of meeting increased college enrollment, the needs for more graduates in science and engineering, and the increasing demands being placed on professional men in the physical sciences.

The Karl Taylor Compton Laboratories will be dedicated during a program commemorating the vision of Dr. Compton in advancing the frontiers of educational and scientific knowledge. Among those taking part in this program will be: Vannevar Bush, '16, Chairman of the M.I.T. Corporation; James R. Killian, Jr., '26, President of M.I.T.; Thomas J. Watson, Jr., President of International Business Machines Corporation; and George R. Harrison, Dean of the School of Science. The nuclear reactor, now under construction, and the Computation Center in the Compton Laboratories will also be open for inspection.

A pre-dinner gathering on the green of Briggs Field will provide opportunity to visit with classmates and other friends. The Alumni Banquet in Rockwell Cage will be followed by a minimum amount of business of interest to all Alumni.

Feature of the evening will be a performance of the Boston Pops Orchestra, under the direction of Arthur Fiedler. For the first time, this famous orchestra will perform in the Institute's acoustically superb Kresge Auditorium.

I.R.A. Regatta

■ The M.I.T. Crew will participate in the 55th annual regatta of the Intercollegate Rowing Association, to be held at Onondaga Lake, Syracuse, N.Y., on June 22. This will be the sixth consecutive year that Onondaga Lake will be the race site, and 12 schools will be represented – Boston University, California, Columbia, Cornell, Dartmouth, M.I.T., Navy, Pennsylvania, Princeton, Stanford, Syracuse, and Wisconsin.

There will be three races – the three-mile varsity and junior varsity, and the two-mile freshman races. This annual event draws rowing fans from all parts of the country to support their favorite crews. Tickets and further information may be obtained from the Syracuse Regatta Association, Department of Athletics, Syracuse University, Syracuse 10, N.Y.

Webster Professor

■ The internationally known French physicist Pierre Aigrain has been appointed Visiting Webster Professor of Electrical Engineering at the Institute, according to an announcement by C. Richard Soderberg, '20, Dean of the School of Engineering. In announcing the appointment, Dean Soderberg said:

"Dr. Aigrain is not only considered one of the outstanding younger European scientists, but is also a world expert in theoretical and experimental phases of research on semiconductors, those materials which are giving us such revolutionary new circuit elements as transistors."

The Webster Chair was established at M.I.T. in 1952 under a grant of $400,000 from the Edwin Sibley Webster Foundation in memory of the late Mr. Webster, one of the Institute's most distinguished Alumni. While occupying the chair, Dr. Aigrain will give a series of lectures on "Modern Developments in Solid State Technology and Their Role in Communications Systems."

Edwin S. Webster, for whom the chair is named, was graduated from M.I.T. in 1888 and founded with his M.I.T. classmate, the late Charles A. Stone, the national organization of Stone and Webster, Inc., the country's first electrical engineering consulting firm.

Dr. Aigrain, who is only 32, is professor of physics at École Normale Supérieure in Paris, where he is in charge of semiconductor research. One of the youngest men ever to be appointed to such a position, he is also a member of the French Atomic Energy Commission and an adviser to SHAPE (Supreme Headquarters Allied Powers in Europe). Dr. Aigrain is in close touch also with fields of military electronics and has visited the United States several times under the auspices of the U. S. Air Force. Professor Aigrain, who came to M.I.T. during the month of May, was graduated from the French Naval Academy in 1944 and took the degrees of master of science and doctor of science at Carnegie Institute of Technology in 1946 and 1948.

Meeting No. 324

■ President Theodore T. Miller, '22, presided at the 324th meeting of the Alumni Council held at the Faculty Club on April 29, which was attended by 140 members and guests. As has been customary, the early portion of the meeting was devoted to matters of alumni business, whereas two speakers from the Institute's staff – Irwin W. Sizer, Head of the Department of Biology, and Carl F. J. Overhage, Director of Lincoln Laboratory – provided information in entertaining manner on recent developments at the Institute.

As Secretary, Donald P. Severance, '38, reported that 11 members of the M.I.T. staff or Alumni Council, between March 11 and April 27, visited local clubs, including those in London, Bombay, Monterrey, and Montreal. It was also announced that the Committee on Audit and Budget had reviewed the Treasurer's proposed budget for the coming year, which was approved by the Executive Committee. An unexpended surplus from last year's operation is to be returned to the Alumni Fund.

On the Horizon

June 10, 1957 – 23d Alumni Day, 1957, M.I.T. Campus in Cambridge.

September 6–7, 1957 – 2d Alumni Officers' Conference, M.I.T. Campus in Cambridge.

December 7, 1957 – 11th M.I.T. Alumni Regional Conference, Pittsburgh, Pa.

The results of elections of the M.I.T. Alumni Association, as recorded on page 395, were announced, and committee nominations for the coming year were submitted for vote of the Council.

As chairman of the Alumni Fund Board, Avery H. Stanton, '25, reported that, at the end of April, 10,905 Alumni had contributed a total of $451,550 to the Alumni Fund. This represents an increase of 14.6 per cent in number of Alumni contributing, and 5.6 per cent increase in amount over corresponding figures for last year. Under the direction of Joseph E. Conrad, Regional Director of the Alumni Fund, regional solicitations in 73 areas have been emphasized this year and an average of 57 per cent participation has been achieved. In half of the regions, regional chairmen have been appointed for next spring's campaign.

The Executive Committee has approved the recommendation of the Alumni Fund Board that the sum of $100,000 be allocated for M.I.T. Alumni Fund National Scholarships to be expended at a rate not exceeding $25,000 per year for the period 1957-1961, and that a sum not exceeding $35,000 be allocated for scholarships for the academic year 1957-1958 to aid those who have received Alumni Fund Scholarships in the freshman year, 1956-1957.

Plans for the Alumni Day Conference on "Today's Science—Tomorrow's Promise," as reported on page 396, were announced by Henry B. Backenstoss, '34, chairman of the Alumni Day Conference.

Professor Sizer spoke on "What's Ahead in Medical Research." Dr. Sizer's talk was well received and caused many questions to be asked. Dr. Sizer's article (page 423 of this issue) covers essentially the same subject presented before the Council and therefore his talk will not be summarized here.

For security reasons, the remarks made by Dr. Overhage are not reproduced here.

Research for High School Teachers

■ An opportunity for high school science teachers to do research of their own choosing during the coming summer at the Institute was announced in April by James M. Austin, '41, Director of the M.I.T. Summer Session. In making this announcement Dr. Austin said:

"The Westinghouse Educational Foundation has made available 24 fellowships of $800 each to be awarded to teachers selected by M.I.T. to participate in scientific research currently being conducted at the Institute. The teachers selected for the program will, in effect, join the research staffs in various departments in the School of Science at M.I.T. for an eight-week period this summer."

Individuals Noteworthy

■ Prominent in the spring news were 31 promotions, elections, or appointments as set forth below:

Philip H. Chase, '09, as Chairman of the Electrical Standards Board . . . *Philip B. Watson, '17,* as Vice-president of the Manufacturers Association of Connecticut . . . *Roy L. Johnson, '18,* as Vice-president of the National Life Insurance Company, Montpelier, Vt.;

Edwin D. Ryer, '20, as a Trustee of the Massachusetts Memorial Hospitals succeeding *George B. Glidden, '93,* retiring President of the Trustees . . . *Dana C. Huntington, '21,* as President of the Dennison Manufacturing Company . . . *Latimer F. Hickernell, '22,* as Treasurer of the American Institute of Electrical Engineers;

William M. Hoge, '22, as Chairman of the Interlake Iron Corporation, Cleveland . . . *Paul A. Heymans, '23,* as Chairman of the Vatican Section of the 1958 World's Fair, Brussels, Belgium . . . *Donald S. Cunningham, '26,* as Vice-president of Hersey Manufacturing Company;

James R. Killian, Jr., '26, as a Director of Research Corporation . . . *Samuel S. Auchincloss, '27,* as President and Chairman of Tracerlab, Inc. . . . *James A. Lyles, '27,* as a Senior Vice-president of First Boston Corporation;

Delmer S. Fahrney, '30, as Chairman of the National Investigations Committee on Aerial Phenomena, founded by citizens interested in interstellar communication . . . *Brigadier General Robert J. Fleming, Jr., '31,* as Commanding General of ADSEC, the advanced section of the European communications zone, at Verdun, France . . . *Edward B. Hubbard, '31,* as a Partner of Coffin and Burr, Boston;

Walter C. Voss, '32, as national Vice-president of Tau Beta Pi . . . *Colonel Carroll T. Newton, '33,* as District Engineer, U.S. Corps of Engineers, at Los Angeles . . . *Leburton D. Webster, '33,* as Assistant Controller of Raytheon Manufacturing Company;

Charles F. Hill, '34, as General Factory Manager of the Racine, Wisc., plant of Massey-Harris-Ferguson, Inc. . . . *John A. Hrones, '34,* as Vice-president for Academic Affairs, Case Institute of Technology . . . *Clarence D. Davis, '35,* as Associate Professor of Obstetrics and Gynecology, Yale Medical School;

Gervais W. Trichel, '35, as President of Amplex Division, Chrysler Corporation . . . *James D. McLean, '37,* as President of Hoffman Laboratories, Inc., Los Angeles . . . *Duane O. Wood, '37,* as Vice-president in Charge of Operations, Lockheed Aircraft Service, Inc.;

Louis R. Forbrich, '38, as General Manager of the Cement Division, Pittsburgh Coke and Chemical Company . . . *Hugh F. Kennison, '39,* as Vice-president in Charge of Engineering and Research, Lock Joint Pipe Company . . . *Richard L. Steiner, '39,* as Commissioner of the Federal Urban Renewal Administration;

Roy E. Nelson, '41, as Vice-president of American Gilsonite Company, Salt Lake City . . . *John E. Yocum, '44,* as Director of Technical Services for the Bay Area Air Pollution Control District, San Francisco . . . *H. Rush Spedden, '50,* as Director of Research for the Union Carbide Ore Company, a division of Union Carbide Corporation . . . *Robert H. Lucas, '51,* as Executive Vice-president of the Pittsburgh Steamship Division, United States Steel Corporation.

■ Special honors recently announced or awarded to Alumni and members of the Institute Faculty include:

To *Robert B. Sosman, '04,* the Purdy Award, by the American Ceramic Society . . . *Arthur C. Willard, '04,* honorary membership, by the American Society of Heating and Air Conditioning Engineers;

To *Erwin H. Schell, '12,* the grade of Fellow, by the American Society of Mechanical Engineers . . . *Jerome C. Hunsaker, '12,* the Distinguished Service Medal, by the National Advisory Committee for Aeronautics;

To *Raymond C. Reese, '20,* the Alfred E. Lindau Award, by the American Concrete Institute . . . *Finley B. Laverty, '25,* designated as the engineer who has done most for the civil engineering profession in Southern California during the past several years, by the Los Angeles Section of the American Society of Civil Engineers;

To *J. Frederic Walker, '25,* the 1957 Schoellkopf Medal, by the Western New York Section of the American Chemical Society . . . *James R. Killian, Jr., '26,* the Exceptional Civilian Service Award, by the Department of the Army;

To *Mrs. Edith L. R. Corliss, '41,* a Silver Medal for Meritorius Service, by the Department of Commerce . . . *T. William Lambe, '44,* a second Desmond Fitzgerald Medal, by the Boston Society of Civil Engineers . . . *José M. Bosch Aymerich, '46,* First Medal in Architecture at the Festival International d'Architecture et du Art Monumental in Paris, France;

To *Nicholas A. Milas,* Associate Professor of Organic Chemistry, an honorary doctorate of science, by Coe College;

To *C. Gardner Swain,* Associate Professor of Chemistry a $1,000 prize for outstanding investigations in theoretical chemistry, by the American Chemical Society;

To *Giorgio D. de Santillana,* Professor of the History of Philosophy and Science, *Victor F. Weisskopf,* Professor of Physics, *Kenkichi Iwasawa,* Associate Professor of Mathematics, *Erik L. Mollö-Christensen, '48,* Assistant Professor of Aeronautical Engineering, and *Gregory Tucker,* Lecturer in Music, 1957 Fellowship Awards, by the John Simon Guggenheim Foundation.

■ Among the Alumni to whom birthday congratulations are appropriate during this month are two due to celebrate 90th anniversaries, two their 85th, and two their 80th, namely:

Born in June, 1867 – *Miss Ada M. Fitts, '96,* on the 4th; and *David S. Hawkins, '92,* on the 24th;

Born in June, 1872 – *Frank L. Harlowe, '96,* on the 3d; and *Dorville Libby, Jr., '95,* on the 24th;

Born in June 1877 – *Herbert R. Stearns, '00,* on the 17th; and *Harry M. Harps, '00,* on the 19th;

With these six, the rolls of the Alumni Association will include a total of 53 living nonagenarians and 593 octogenarians.

Twenty-five Years Ago This Month . . .

■ On June 7,1932, commencement exercises at Symphony Hall marked the graduation of the Institute's 65th class. Of the total of 697 degrees then awarded, 461 went to bachelors of the Class of 1932 and 236 to candidates for advanced degrees, namely: 15 doctorates of philosophy and 12 of science, 204 masters of science and 5 masters in architecture.

The academic procession was led by Alexander Macomber, '07, who four years earlier had been the Alumni Association's 35th President; and next, heading the group of distinguished guests of honor, came Karl T. Compton, President, escorting the commencement speaker, who was Sir Henry Thornton, President of the Canadian National Railways.

Then, in order, followed Corporation members marshaled by Walter Humphreys, '97 (the 9th Secretary of the Alumni Association, from 1907 to 1923); members of the 50-year Class of 1882 marshaled by Dean Samuel C. Prescott, '94 (the 34th President of the Alumni Association, in 1927-1928); and members of the Faculty marshaled by Professor George E. Russell, '00.

Finally, came the long procession of degree candidates led by Donald B. Gilman, President of the Class of 1932, and its three elected marshals: William H. Barker, John Lawrence, and Thomas B. Rhines – which four, respectively, are in 1957: Factory Manager, Electric Regulator Company, Norwalk, Conn.; Sales Supervisor, Apex Tire and Rubber Company, Pawtucket, R.I.; President, Joy Manufacturing Company, Pittsburgh, Pa.; and Assistant Chief Engineer, Hamilton Standard Division, United Aircraft Corporation, Hartford, Conn.

Mr. Sloan . . . at the time of his election to life membership on the Corporation

. . . Alfred P. Sloan, Jr., '95, was elected a life member of the Institute Corporation, of which he had been an alumni term member during 1926-1931.

Visiting Committee Report on Physics

■ Members of the Faculty of the Department of Physics met with members of the Visiting Committee on this Department on April 6, 1956.* During this meeting the undergraduate, graduate, and research programs of the Department were carefully reviewed.

In recent years the traditional approach to physics teaching has not been as successful in giving the undergraduate an adequate perspective of modern physics and its new philosophies as is desirable. In an effort to meet current educational needs more effectively, the Department is attempting to compress and integrate the presentation of classical physics with modern physics and its concepts. An aim of the new program is to present, in two years of undergraduate study, a much larger view and understanding of modern physics than has previously been possible.

The Committee feels that the Department is making good progress in its new experimental teaching program. The students are responding with enthusiasm to the new approach, and the number of failures is surprisingly small. The Committee urged the Department to publish its new material in textbook form at the earliest opportunity so that other universities may take advantage of the Department's pioneering work.

The modernization of undergraduate teaching has extended into the laboratory as well as the classroom. The traditional routine experiments of undergraduate physics have been abandoned, new experiments with challenging interest have been developed and, in spite of the large number of students serviced, a lively laboratory experience is provided. This effort is to be commended and encouraged. The new enthusiastic teaching program is being carried on without detriment to the Department's program of research.

The upward trend of the past few years in number of freshmen electing physics, if continued, will present a major problem in space, facilities, and teaching staff for the Department. One hundred and five freshmen selected physics as a major in 1952, and 180 selected it in 1955. Even should the number of freshmen choosing physics stabilize at this level, within a few years the number of students registered in physics will overtax the Department's space, facilities, and Faculty even with the new Karl Taylor Compton Laboratories. The total, including graduate students, in the Department is now 591. Even with a leveling off in freshman input, the number will approach 900 in a few years.

When completed, the Compton Laboratories will provide more effective and improved housing for physics instruction and research, but it will add little to the capacity of the Department. Within the next few years, therefore, major problems in providing space, facilities, and instructing staff to meet the Department's growing needs and responsibilities, will develop.

The Committee was most favorably impressed with the teaching and research activities of the Department. The Committee's only recommendation is that a sound estimate of student population of the Department for the next several years be made and that space, facilities, and Faculty requirements for the expanding student body be planned for as early as possible to insure that the high quality of the work of the Department not suffer from overcrowding, shortage of facilities, and overloading of Faculty.

After review by the Corporation and Executive Committee of the Institute, the Committee's report of April 6 was received for publication in The Review last October 25.

* Members of this Committee for 1955-1956 were: Mervin J. Kelly, chairman, H. B. Richmond, '14, Robert B. Lindsay, '24, Henry A. Morss, Jr., '34, Leonard I. Schiff, '37, Edwin H. Land, Alfred L. Loomis, I. I. Rabi, and C. Guy Suits.

M.I.T. Photos

A. A. Ashdown, '24 E. L. Cochrane, '20 A. R. Davis W. C. Eberhard, '14 W. H. McAdams, '17

G. Scatchard W. E. Stanley A. L. Townsend, '13 C. M. Wareham, '16 W. L. Whitehead, '13

To Other Assignments

■ Nine members of the Institute's Faculty and two members of the M.I.T. Administration will retire effective July 1. Portraits of the 11 appear on these two facing pages.

Avery A. Ashdown, '24, will continue to serve as secretary of the Society of Arts and as master of the Graduate House following his retirement as Associate Professor of Organic Chemistry. In 1956 a portrait of Dr. Ashdown was presented to the Graduate House by former residents of the House in appreciation of his friendship and guidance during the years he has served as master there.

Edward L. Cochrane, '20, Vice-president for Industrial and Governmental Relations, has also served as head of Course XIII and as Dean of the School of Engineering. Additional data regarding Admiral Cochrane appear on page 396.

Arthur R. Davis, Associate Professor of Inorganic Chemistry, a member of the Institute's Department of Chemistry since 1930 has had wide experience in scientific and educational fields. He received the B.A. degree from Wesleyan University (1915) and the M.A., and Ph.D. degrees from Harvard University (1925 and 1930). He was a member of the staff and acting head of the Department of Chemistry at Middlebury College and also taught chemistry at Harvard University.

Walter C. Eberhard, '14, Assistant Professor of Engineering Graphics, has been associated with the Institute's engineering drawing and graphics program for 38 years. He served as assistant in Civil Engineering for two years, left the Institute between 1916 and 1919 when he returned as instructor in graphics. From 1923 to 1933 Professor Eberhard was director of the M.I.T. Mining Camp in Dover, N. J.

William H. McAdams, '17, Professor of Chemical Engineering, received the B.S., M.S., and honorary D.Sc. degrees from the State University of Kentucky (1913, 1914, and 1945), and the S.M. degree from M.I.T. (1917). For his work in heat transmission, Dr. McAdams received the Worcester Reed Warner Medal of the American Society of Mechanical Engineers in 1954.

George Scatchard, Professor of Physical Chemistry, elected to membership in the National Academy of Sciences in 1946, received the B.A. degree from Amherst College (1913) and the Ph.D. from Columbia University (1917). In 1954 the Northeastern Section of the American Chemical Society awarded him the biennial Theodore William Richards Medal for his work on the physical chemistry of solutions. During World War II he was scientific adviser to the Deputy Military Governor in Germany.

William E. Stanley, Professor of Sanitary Engineering, with degrees from Kansas State College and Purdue University (1912 and 1916) came to M.I.T. in 1944 after a varied and active career in government and industrial service. For five years prior to World War II he was professor of sanitary engineering at Cornell University, and from 1941 to 1944 served as a major in the Corps of Engineers.

Arthur L. Townsend, '13, received the S.B. degree from M.I.T. (1913) and served as supervisor engineer of the Massachusetts Bonding and Insurance Company before joining the M.I.T. Faculty in 1919. He has served for many years as undergraduate and alumni placement officer for his Department where he is associate professor of mechanical engineering. He is director of the Lowell Institute School — a post he will continue to hold. Professor Townsend is a

former vice-president of the M.I.T. Alumni Association (1937–1939) and has been a member of many alumni committees.

Charles M. Wareham, '16, Associate Professor of Inorganic Chemistry, received the S.B. degree from M.I.T. (1916) and has been a member of the Institute's staff for 41 years. He joined the staff as assistant in drawing and descriptive geometry immediately upon graduation, and the following year became an instructor in the chemistry of sanitation. In 1935 he was appointed assistant professor, and in 1941 became associate professor of inorganic chemistry.

Walter L. Whitehead, '13, Associate Professor of Geology, received the S.B. and Ph.D. degrees from M.I.T. (1913 and 1917). He worked as consulting geologist and mining engineer in various parts of the world and joined the Department of Geology in 1928 as lecturer. He became assistant professor in 1942 and associate professor in 1947. He will direct the M.I.T. Summer Camp at Antigonish, N.S., as he has since it was organized in 1948.

William Emerson: 1873–1957

■ The death at his Cambridge home on May 4 of Professor William Emerson, Dean Emeritus of M.I.T.'s School of Architecture and life member of the Corporation, has been noted by The Review with regret. He was 83 years old.

After a distinguished career as practicing architect in New York City, where he became noted for his design of model tenement houses and bank buildings, Dr. Emerson came to M.I.T. in 1919 to begin 20 years' active service as professor, head of the Department of Architecture, and dean. He was elected a life member of the Corporation in 1939.

Dr. Emerson was graduated from Harvard in 1895 and studied architecture at Columbia University and at L'Écoles de Beaux Arts in Paris. During World War I he served in France as director of the American Red Cross Bureau of Construction, and was awarded the ribbon of Chevalier of the Legion of Honor.

Widely known for his contributions to architectural education as chairman of the Educational Committee of the American Institute of Architects, Dr. Emerson had for many years also been an active leader in numerous architectural societies. He was formerly an advisory architect for Radcliffe College, chairman of the Unitarian Service Committee, chairman of the Corporation of Simmons College, and president of the Civic Association for the United Nations. He was an honorary member of Phi Beta Kappa at Harvard and was awarded an honorary doctorate in 1939.

Time to Refire

■ Thirty-two years ago next month The Review published a three-page, fact-filled article entitled "Shoes and Ships and Sealing Wax" in which "a new and welcome Review contributor gives his impressions of 'The Day at the Institute.'" The author was J. J. Rowlands, whose name has regularly appeared on The Review's masthead for the past third of a century. Sometimes Mr. Rowlands was listed as contributing editor, sometimes as editorial associate, sometimes as consultant. But whatever the title, he was always regarded as a "perennial friend of The Review," and a competent and sympathetic counselor to its editors. He was made an honorary member of the M.I.T. Alumni Association in 1955 and, upon taking leave of absence last year, became consultant to The Review. On July 1, Mr. Rowlands joins the ranks of those who attain emeritus status.

Born in Aberdeen, N. C., on June 19, 1892, Mr. Rowlands received his education in military academies in the United States and in higher institutions of learning in Toronto. He engaged in surveying and field engineering in Canada for several years before turning to editorial work for the Springfield (Mass.) *Union*. He was assistant news editor and, subsequently, New England and Eastern Canadian Manager for the United Press Association between 1916 and 1923. He was managing editor of *National Sportsman* from 1923 until he joined the Institute staff on February 9, 1925, as Director of the M.I.T. News Service.

M.I.T. Photo

John J. Rowlands

At present, the news and public relations activities of the Institute are conducted by a staff of five men and eight women. But for two decades – including the active period during World War II – the M.I.T. News Service activities were the sole responsibility of John J. Rowlands. The esteem with which his professional work is regarded can best be ascertained from the remarks of a competent and disinterested observer. In the Boston *Herald* of Saturday, February 18, 1950, Edward A. Weeks, Editor of *The Atlantic Monthly*, wrote: "In my judgment, the best public relations in the college world over the past 25 years have been those maintained by James Rowlands at the Massachusetts Institute of Technology."

Mr. Rowlands is author of *Cache Lake Country; Life in the North Woods*, and published a monthly news letter, *Cache Lake Letter*, from 1946 to 1949. He is author of articles in *The Atlantic Monthly*, *Boys' Life*, The Technology Review, and several sports magazines.

Mr. Rowlands has just completed a new home in Cohasset, and currently he is engaged in writing a sequel to his *Cache Lake* book and has other writing objectives as well. Thus, he has by no means signed "30" to his last piece of copy; he is merely taking time out to refire.

M.I.T. Photos

W. Ambrose | R. L. Bishop | J. M. Blum | B. T. Feld | R. J. Hansen, '48

Promotions

■ The 10 young men whose portraits appear on this page have been promoted to full professorship, 14 others have been advanced to associate professorship, and 15 more have been advanced from instructor to assistant professor. Sixteen Faculty promotions were in the School of Engineering, 15 in the School of Science, 5 in the School of Humanities and Social Studies, and 3 in the School of Industrial Management. All promotions are effective on July 1.

The 10 reaching the top of the academic ladder this year are: Warren Ambrose, Department of Mathematics; Robert L. Bishop, Department of Economics; John M. Blum, Department of Humanities; Bernard T. Feld, Department of Physics; Robert J. Hansen '48, Department of Civil and Sanitary Engineering; Harold S. Mickley, '46, Department of Chemical Engineering; René H. Miller, Department of Aeronautical Engineering; Walter A. Rosenblith, Department of Electrical Engineering; George W. Whitehead, Department of Mathematics; and William A. Wilson, Department of Mechanical Engineering.

The following 14 men have been promoted to associate professor: Nesmith C. Ankeny, Department of Mathematics; Walter A. Backofen, '46, Department of Metallurgy; Raymond F. Baddour, '49, Department of Chemical Engineering; William H. Dennen, '42, Department of Geology; David A. Huffman, '53, Department of Electrical Engineering; Thomas B. King, Department of Metallurgy; William L. Kraushaar, Department of Physics; Leo B. Moore, '37, School of Industrial Management; John F. Nash, Department of Mathematics; Norman A. Phillips, Department of Meteorology; Lucian W. Pye, Department of Economics and Social Science; Robert R. Rathbone, Department of Humanities; J. Lowen Shearer, '50, Department of Mechanical Engineering; and Kenneth N. Stevens, '52, Department of Electrical Engineering.

The 15 men listed as follows have been promoted to assistant professor: Walter F. Cannon, Department of Humanities; Stanley E. Charm, '57, Department of Food Technology; F. Albert Cotton, Department of Chemistry; George J. Fuld, '53, Department of Food Technology; Brison D. Gooch, Department of Humanities; S. William Gouse, '53, Department of Mechanical Engineering; Edward Herbert, Department of Biology; Norman H. Meyers, '54, Department of Electrical Engineering; William R. Moore, Department of Chemistry; Roger W. Prouty, Department of Humanities; James E. Roberts, '51, Department of Civil and Sanitary Engineering; Robert A. Schluter, Department of Physics; Campbell L. Searle, '51, and Richard D. Thornton, '54, both of the Department of Electrical Engineering; and Nathan S. Wall, '54, of the Department of Physics.

Bohr to be Compton Lecturer

■ Niels Bohr, Danish physicist, will be in residence at the Institute for a month next fall as Karl Taylor Compton Lecturer. Announcement that Dr. Bohr had accepted appointment to the lectureship was made on May 8 by James R. Killian, Jr., '26, President. It was announced previously that Dr. Bohr would come to Washington, D.C., late in October to receive the $75,000 Atoms for Peace Award.

Dr. Bohr will be the first to hold the Compton Lectureship which has been established in honor of the late Karl Taylor Compton, former M.I.T. President and Chairman of the Corporation.

H. S. Mickley, '46 | R. H. Miller | W. A. Rosenblith | G. W. Whitehead | W. A. Wilson

School of Industrial Management Holds Convocation

After five years of operation the newest M.I.T. school surveys its accomplishments in education for management

A TECHNOLOGY REVIEW REPORT

In celebration of the fifth anniversary of the founding of the School of Industrial Management at the Institute, a convocation emphasizing the education of a new kind of industrial leader was held at M.I.T. on Tuesday, April 9. Some 500 leaders of business and industry from all parts of the country, as well as M.I.T. representatives (especially from the School of Industrial Management), attended this eventful occasion in Cambridge.

The morning session opened at 10:00 A.M. in Kresge Auditorium with E. P. Brooks, '17, Dean of the School of Industrial Management, presiding. The morning program included addresses on: "Tomorrow's Industrial Leadership" by Dean Brooks; on "Systems Technology and Industrial Dynamics" by Jay W. Forrester, 6–45, Professor of Industrial Management and formerly Head of the Computer Division of Lincoln Laboratory; and on "The Human Side of Enterprise" by Douglas M. McGregor, Professor of Industrial Management.

At the catered luncheon, served in Rockwell Cage adjacent to the Kresge Auditorium, Julius A. Stratton, '23, Chancellor of M.I.T., presided. Following the luncheon, Eli Shapiro, Associate Dean of the School of Industrial Management and Professor of Finance, spoke on "Financial Forces in Industrial Growth."

The afternoon session, in Kresge Auditorium, was devoted to a panel discussion on "The Evolving Role of the Corporate Director" with Lyman Bryson, radio moderator, as chairman. Members of the panel were Vannevar Bush, '16, Chairman of the M.I.T. Corporation and formerly president of the Carnegie Institution of Washington; Eugene V. Rostow, Dean of the Law School of Yale University; David A. Shepard, '26, a Director of the Standard Oil Company (New Jersey); and Sidney J. Weinberg, Senior Partner of Goldman, Sachs and Company.

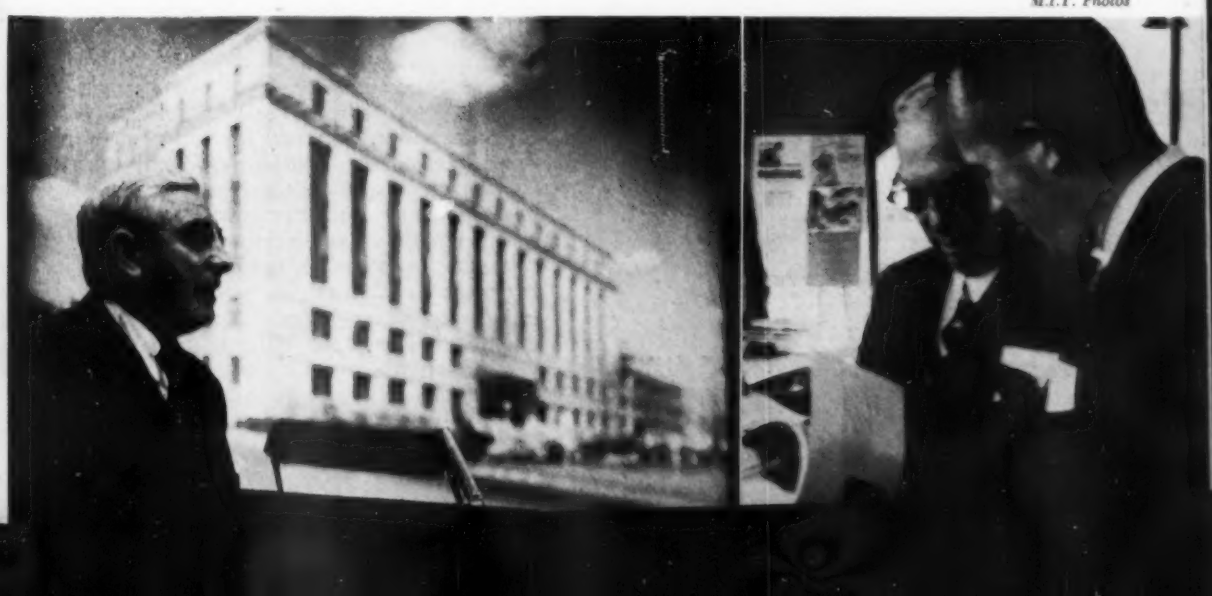
Dinner in the evening was at the Hotel Sheraton Plaza in Boston. James R. Killian, Jr., '26, President of M.I.T., presided at the dinner at which Alfred P. Sloan, Jr., '95, former president and Honorary Chairman of the Board, General Motors Corporation, was guest of honor. Cleo F. Craig, Chairman of the Board, American Telephone and Telegraph Company, gave the principal address entitled "Tomorrow's Managers."

Morning Session

The morning session was opened at 10:00 A.M. by Dean Brooks, who was the first graduate of Course XV. After welcoming his guests to the convocation and commenting on the splendid attendance, Dean Brooks reviewed the history of the School of Industrial Management in an address entitled "Tomorrow's Industrial Leadership." He recalled that the School was the co-operative result of the work of a great industrialist and of a great educator – Alfred P. Sloan, Jr., '95, and Karl T. Compton, respectively. These men foresaw the need for a new kind of education,

E. P. Brooks, '17, first graduate of Course XV and now Dean of the School of Industrial Management (left), *opens the convocation. Alfred P. Sloan, Jr., '95 (whose realistic appraisal of American educational needs helped found the School), discusses the convocation program with Robert M. Kimball, '33, Secretary of the Institute.*

M.I.T. Photos



Douglas M. McGregor, Professor of Industrial Management, speaks on "The Human Side of Enterprise."

following in the tradition of Western culture, to help meet the needs of a vast and rapidly growing industrial and technological society.

New conditions, Dean Brooks reported, call for a new kind of education, and efforts are being made at M.I.T. to provide such education for tomorrow's leaders in business and industry. It is clear that executives need to have a good knowledge of science and engineering and will need powers and methods of analysis vastly superior to those which were available to them in the past. History has shown – and many M.I.T. graduates have demonstrated – that the discipline of science and engineering provides a sound basis for executive development. It seems logical, therefore, for future executives to obtain their early education and academic training in an environment in which engineering and science – along with architecture – play the major role.

It is from this point of view that the M.I.T. School of Industrial Management was opened in the fall of 1952. The School was made possible by Mr. Sloan's faith in the need for developing executives who understand engineering and science, by the support he gave in financing the School's first years of operation, and by purchase of the Sloan Building for the School.

General view in the lobby of the Kresge Auditorium, as guests registered for a full day of convocation activities.

What, one may ask, is the general objective of the School for Industrial Management, and wherein does it differ from other business schools? The School has adopted, as guiding principle, the following aims:

1. Education for general management – rather than for specialized staff functions – is its goal.

2. The executive leader needs to know the nature of man as well as technical operations, and hence topics in the social sciences – such as psychology, sociology, history, labor relations and communication – are emphasized in training its students.

3. It is recognized that no school can teach a man all he needs to know, that much of his knowledge and usefulness will come from experience gained in industry. For this reason, there is a division of work between industry and the university in training students in the School of Industrial Management. At the university, the student should learn the methods of analysis; in industry, he has his best opportunity to become acquainted with modern industrial practice.

4. Education can thrive only in an atmosphere charged with the excitement of research and discovery. Hence, the future executive must know how to use the new techniques that are becoming available for the handling of facts.

5. Finally, it is important to recognize what can be done in an educational institution and what cannot be done. How, for example, can the student be taught boldness, initiative, judgment, sense of proper timing, and, most important of all, character? If such topics can be taught at all, they can be taught most effectively by example through contact with recognized leaders in these areas of human conduct.

With such aims, the School was established in 1952. Where do we stand at the present time?

The School of Industrial Management now conducts four educational programs. At least two – the undergraduate and graduate programs – follow traditional university effort; the other two represent bold ventures in a new and important area of advanced training for mature executives of proven ability.

The undergraduate program of the School, leading to a bachelor's degree, is not exactly new and had its genesis in Course XV, established by Erwin H. Schell, '12, Professor of Industrial Management, Emeritus, prior to World War I. Students in Course XV spend 75 per cent of their time studying engineering or science topics and the remaining 25 per cent is devoted to topics dealing with business functions – in combining men, money, and materials to serve a useful purpose.

There also is a two-year graduate course, leading to a master's degree, which was put into operation in 1952. This, too, is based largely on good background in science and engineering. The first year subjects are generally prescribed, but in the second year the student has great freedom to follow courses of his own selection. At present, approximately 100 students are enrolled in this graduate course of studies.

In addition to these more or less traditional courses, two courses of study are in operation for men already in industry. These postgraduate programs are highly exacting and exciting and are given to promising young men who have already shown indication of potential leadership in their companies.

The convocation luncheon was held in the Rockwell Cage. Head table guests shown here, from left to right are: (1) Howard W. Johnson, Associate Professor of Industrial Management; (2) William F. Massey, President of the Graduate Management Society; (3) Ralph E. Freeman, Professor of Economics and Head of the Department of Economics and Social Science; (4) John T. Norton, '18, Chairman of the Faculty; (5) C. Richard Soderberg, '20, Dean of the School of Engineering; (6) E. P. Brooks, '17, Dean of the School of Industrial Management; (7) J. A. Stratton, '23, Chancellor of M.I.T.; (8) Eli Shapiro, Associate Dean of the School of Industrial Management (hidden by lectern); (9) George R. Harrison, Dean of the School of Science; (10) John E. Burchard, '23, Dean of the School of Humanities and Social Studies; (11) Thomas M. Hill, Associate Professor of Industrial Management; (12) Gary J. Dischel, '57, President of the M.I.T. Management Society; and (13) W. Van Alan Clark, Jr., '42, Assistant Dean of the School of Industrial Management.

The first of these is the Sloan Fellowship Program for men in their early to mid-thirties. Such men come to study at M.I.T. for a year, with their families, during which time they have a leave of absence from their companies.

The second course, started in 1956, is intended for about 20 men of 40 to 50 years of age who spend 10 weeks in further study to advance their executive ability.

The Institute's executive training programs have now passed beyond the experimental stage. Industry is coming to realize that only by coming back to class can modern executives keep fully abreast of the great and rapid surge of learning that is being generated. The military services have already recognized this need and send their officers back to service and command schools with the War College at the top. At the School of Industrial Management, Dean Brooks felt, M.I.T. is establishing a sort of War College with emphasis on the training of leaders for industry and technological leadership, rather than for leadership in the arts of war. As evidence of the success of this type of program, Dean Brooks cited the fact that industry is turning more and more to colleges to provide the necessary leadership.

Dean Brooks then introduced Professor Forrester, who spoke on "Systems Technology and Industrial Dynamics." Professor Forrester's address may be found on page 417.

The Human Side of Enterprise

As the last speaker at the morning session, Douglas M. McGregor, Professor of Industrial Management, spoke on "The Human Side of Enterprise." It was Dr. McGregor's belief that, in the next quarter century, major developments will be made in the social sciences. So far, this is a pious hope to which we can look forward with great anticipation, but there is little else to go by at the moment.

The present view is that management's task is: (1) to organize men, money, materials, and machines to a useful economic end result; (2) to provide effective motivation to get things done by people engaged in the business enterprise; (3) to recognize that, without motivation, people are passive, so that the urge to drive is a task of management. Behind this conventional theory of management's role is the general belief that, when left to himself, man is indolent, self-centered, gullible, resistant to change, will do only the minimum amount of necessary work, and needs to be spurred to action because he usually lacks initiative. Our present managerial efforts fully reflect these attitudes. In its efforts to accomplish its task, management sometimes goes to the "soft" or the "hard" extreme.

The most important things for management to recognize are the factors affecting personal motivation. As soon as one of man's needs is filled, another appears to take its place. These needs appear in a well-established order, beginning with the most basic, and leading progressively to the most complex.

Our most basic needs are for food, clothing, and shelter, but once these physiological needs are satisfied, man strives to fill other needs and is motivated toward this end. A satisfied need is not, therefore, a motivator of behavior, nor does it make for a movement toward change or betterment.

After man's basic needs are satisfied, his need for safety assumes major importance; some call this a need for security. But Dr. McGregor believes this is incorrect; man looks for the "fairest break possible" in the treatment he receives, rather than for security as such. He recognizes there is no complete security in an absolute sense, but wants to stand on an equal and fair footing with his fellow man.

After the safety needs are satisfied – and they can be now in our modern technological society – social needs come to the fore. We recognize the need for acceptance by our associates, for recognition, for praise, for being accepted by the group, for "belonging."

Beyond the social needs come the egoistic needs; these are of greatest importance to management.

These needs are for: (1) self-esteem (self-confidence, independence, achievement, competence and knowledge of one's job, and so on); and (2) reputation (appreciation, status, and respect with which a person is held by his colleagues). The typical organization offers very little opportunity to advance the ego needs of its employees.

Above the ego needs are those for self-actuation, for self-development, for creativeness in the broadest sense of the word. Even less opportunity to fulfill these needs is provided by modern management today.

Professor McGregor stated that deprivation of any of the above human needs has behavioral consequences, and a person frustrated in satisfying motivation needs may be considered as being "sick." If we accept this new concept, we open the door to new areas of research and potential success in the social sciences. We must recognize that man is motivated only to put forth effort to satisfy the next higher need on the scale outlined above.

Failure to recognize that the same means of gratifying personal needs is not equally effective for motivating all persons has deprived management itself of motivation by direction and control; management has been offering motivations which are ineffective and which are irrelevant for the needs to be satisfied. That is, management by direction and control fails to provide proper motivation. A new theory proposed by McGregor holds that:

(1) Management is responsible for organizing elements of the productive enterprise in the interest of economic ends;

(2) People are not by nature passive but become so through conditioning due to their environment;

(3) The abilities and desires present in everyone can be brought to the fore and developed by management;

(4) The essential task of management is to arrange organizational conditions so that people can attain their own goals through individual growth and advancement. Progress with this theory depends for its success upon management by attainment of desired objectives.

Professor McGregor recognized that the elements of his new theory need much experience and experimentation before it is possible to take full advantage of his concepts. Yet, there is hope that in the next quarter century, we can make progress in satisfying the higher goals now that the more basic ones have been reached.

Luncheon

Upon conclusion of these addresses, the audience moved from Kresge Auditorium to the Rockwell Cage where a catered luncheon was served at tables seating about 10 people each. So far as possible, a senior Faculty member of the School of Industrial Management, or a Sloan Fellow, mixed with the guests at each of the tables.

Upon conclusion of the luncheon, Chancellor Stratton spoke briefly on the significance of the work being done in the School of Industrial Management. He pointed out that government, as well as industry, will make increasing demands on those who are well trained in economics as well as in science. In speaking of the educational program of the School of Industrial Management, he indicated that its work reflects the character of M.I.T. The convocation is devoted to the problems of management, and the School of Industrial Management enjoys the respect and support of the Institute. It aims, as does M.I.T., to keep standards high, to attract excellent students through assembling an outstanding Faculty.

This thought provided opportunity to introduce those at the head table, which included: C. Richard Soderberg, '20, Dean of the School of Engineering; George R. Harrison, Dean of the School of Science; John E. Burchard, '23, Dean of the School of Humanities and Social Studies; E. P. Brooks, '17, Dean of the School of Industrial Management; J. A. Stratton, '23, Chancellor; Eli Shapiro, Associate Dean of the School of Industrial Management; Professor John T. Norton, '18, Chairman of the Faculty; Professor Ralph E. Freeman, Head of the Department of Economics; Howard W. Johnson, Associate Professor of Industrial Management; Thomas M. Hill, Associate Professor of Industrial Management; Gary J. Dischel, '57, President of the M.I.T. Management Society, Undergraduate Student Association; William F. Massy, President of the Graduate Management Society of the School of Industrial Management; and W. Van Alan Clark, Jr., '42, Assistant Dean of the School of Industrial Management.

Chancellor Stratton then introduced Eli Shapiro, Associate Dean of the School of Industrial Management (who will be on leave of absence for the next year on studies of his own), who spoke to those attending the convocation on the topic, "Financial Forces in Industrial Growth," as on page 412.

The Corporate Director

Following luncheon, the convocation resumed with the afternoon session in Kresge Auditorium devoted to a panel discussion of "The Evolving Role of the Corporate Director." Panel members were Sidney J. Weinberg, Senior Partner of Goldman, Sachs and Company; Eugene V. Rostow, Dean of the Law School of Yale University; David A. Shepard, '26, Director of the Standard Oil Company (New Jersey); and Vannevar Bush, '16, former President of the Carnegie Institution of Washington and now Chairman of the Corporation of M.I.T. Moderator of this panel was Lyman Bryson, whose radio program "Invitation to Learning" is known to most Americans.

Mr. Weinberg started the discussion by presenting his views on the role of the corporation director. In Mr. Weinberg's opinion, the role of the director does not change much, rather it is the corporation itself that undergoes change. A board of directors usually has inside directors selected from the executives running the company and outside directors who are not on the company payroll. Mr. Weinberg thought that corporations should have a majority of outside directors. The purpose of the board is to act as a buffer between the company and the outside world, to represent all the stockholders, but to consider as well the interests of the country, the community, and the

public. A corporation member has power only during a corporation meeting, and then in an advisory capacity; it is up to the officers of the company to put policies into effect and to manage the company. A board of from 12 to 15 members appears to be of optimum size.

Mr. Weinberg felt that directors should be selected for the breadth of their knowledge and experience. Obviously, they would be mature, older men. But inside directors should not be older than 65 years, and outside directors not older than 70 if they are to perform effectively.

Directors must be equipped with the tools to advise company executives, and these must be supplied by the company officers. Regular board meetings should be held each month; there should be an agenda prepared well in advance; minutes of the previous meeting should be circulated regularly and promptly; counsel should be represented at all board meetings to avoid possible legal entanglements; and directors should receive all pertinent information regarding company activities, policies, and plans to enable directors to do their work well; they should receive copies of all important financial reports.

Directors should have opportunity to meet with younger, able company executives in order that they may know who the company leaders are. An important function of board members is selection of a new chief executive and this can be aided if board members are acquainted with potential candidates from within the company's personnel.

The board member often serves on committees; sometimes he makes his major contributions through such service. Frequently, he has to take reports and financial records home with him for evening study. Finally, the director must have a keen social sense and he must be aware of the human problems of business which are involved.

Dean Rostow spoke next and pointed out that the corporation was only one of a great many institutions of modern society, but that it was regulated in a way different from other social institutions. Churches, labor unions, and educational institutions are other examples of social institutions which are relatively free from legal restrictions, except in a broad sense.

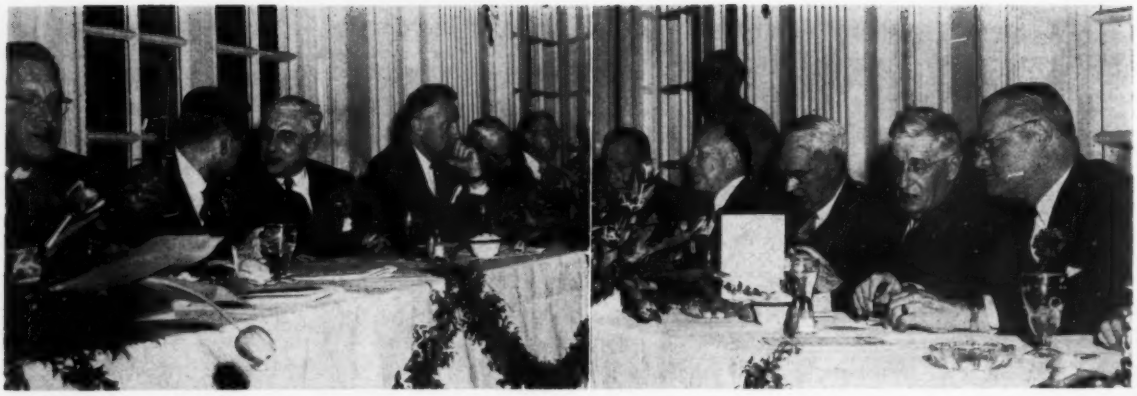
It is well to recognize the directors as trustees who operate under certain statutes. Dean Rostow then asked, "For whom and for what do board members operate?" Dean Rostow expressed the view that so long as directors acted on behalf of the economic interests of stockholders, they were performing in an orderly, well-recognized, and well-established manner. But as soon as they pretend to act in the public interest, there will be others – including politicians – whose claim to act in the public interest is also to be taken into account, and there may be conflict of interests and authority.

Mr. Shepard stated that all of the directors of his firm are inside directors; there are no outside directors, and yet the company operates many companies and offices in all parts of the world. Mr. Shepard pointed out that a holding company provides counsel and co-ordination of individual companies in an effective way, that the directors assure appointment of the best managers and officers, and that they are effective in aiding research progress.

While agreeing that the responsibility of the directors is to provide that the stockholders are adequately represented in the able management of their business, Mr. Shepard held that the raw material – oil in the case under consideration – makes it necessary for directors to do more than look at the stockholders' interests. The corporation must be regarded not only as efficient and profitable in its operations, it must also be regarded as a good citizen in the community. Mr. Shepard pointed out that the company could not thrive in the long run, no matter how much money its stockholders made, if its operations and activities ran counter to the public interest.

▲ *As shown in the illustration at the top of this page, the afternoon session was given to a panel discussion of "The Evolving Role of the Corporate Director." Members of this panel were (left to right): Sidney J. Weinberg, Eugene V. Rostow, Lyman Bryson, who was chairman, David A. Shepard, '26, and Vannevar Bush, '16.*

◄ *At left, James R. Killian,Jr., '26, President of the Institute, speaking at the dinner at the Hotel Sheraton Plaza, appears to have amused his listeners. Other head table honored guests (left to right) included: Cleo F. Craig, J. A. Stratton, '23, and Andrew T. Kearney.*



Honored guests at the head table at the banquet included (left to right): The Reverend Theodore P. Ferris, Rector of Trinity Church; Joseph J. Snyder, 2–44, Treasurer of M.I.T.; E. P. Brooks, '17, Dean of the School of Industrial Management; Wayne J. Holman,Jr., President, Chicopee Mills, Inc.; Alfred P. Sloan, Jr., '95, honorary chairman of Board of General Motors Corporation; and President Killian. In the right-hand illustration, honored guests (left to right) include: Cleo F. Craig, Chairman of Board, American Telephone and Telegraph Company, who gave the main banquet address: J. A. Stratton, '23, M.I.T. Chancellor; Andrew T. Kearney, Partner, A. T. Kearney and Company; Vannevar Bush, '16, Chairman of the M.I.T. Corporation; and Frederick R. Kappel, President of American Telephone and Telegraph Company.

As final speaker on the panel, Dr. Bush stated his view that there is great need for a chief executive to report to and to receive sound advice from someone in operating his plant. A group is needed to review, criticize, and guide the long-range operations of the executives whose responsibility is for the day-to-day operations and management of the firm. The board should support the company executives in their operating activities; if they cannot do this and have lost faith in their chief executive, a new president should be found. It is not sound to leave the company affairs in the hands of any individual or any small group for any length of time without review by some appropriately named agency.

The board must be constituted so that it can select the chief executive for the firm. The chairman of the board should not be the company's chief executive. "If this is so, then what does the chairman of the board do?" asked Dr. Bush.

One of the important roles of a board chairman is to look to it that the board is of proper composition to give most effective advice to the firm's executives. Age is no factor in this regard; in fact, the older a person gets, the more experience he accumulates and – barring ill health – the more valuable he becomes. The chairman of the board can further outside relationships for the company without being too much involved in its daily operations. The board should be composed of able, experienced men of independent thoughts; it should not be a rubber stamp congress.

Where do we get good board members, Dr. Bush asked? Why do men serve on boards? Certainly they get negligible monetary compensation from such service. Men work for pride and satisfaction; the financial rewards are of secondary importance. The real incentive, Dr. Bush felt, is respect of one's fellows which is enhanced by having a post such as a board member. The reason why men struggle is because they have the satisfaction of guiding the affairs of their fellow men; this is the real reason men serve on boards in the majority of cases.

Of course, the board member has a primary responsibility to company stockholders. But the company also has to deal with public relations, community problems, labor relations, and the public as well as its customers and stockholders. Therefore, one cannot look narrowly only at the immediate interests of the stockholder. In fact, Dr. Bush made the point that it is possible for a director to vote against the long-range interests of the stockholder and still be fulfilling his function properly, in some instances.

(Concluded on page 442)

In clockwise order, banqueteers at Table 9 include: (1) Benjamin H. Bristol, '19, (2) Charles A. Chayne, '19, (3) Bob E. Sensman, G. and (4) Oliver L. Bardes, '21. Those at Table 10 include: (1) Richard N. Benjamin, (2) Wilson Compton, (3) Hartley Rowe, (4) William M. Rand, (5) Robert E. Coulson, (6) Horace S. Ford, (7) Robert R. Duncan, and (8) George T. Cottle, '9

Tomorrow's Managers

— will have deep sense of trusteeship, encourage technical progress, distribute authority, provide climate favorable to the development of leaders

by CLEO F. CRAIG

WHEN Dean Brooks invited me to come and talk tonight, and I asked him what I should talk about, he said, "Anything you want to say about the future of management generally."

That made me think of the story about two G.I.'s who came down from the hills of North Carolina and into the Army in World War II. It wasn't long before they found themselves on a troopship bound for England. Neither of them had ever been very far from home before going to camp, or had ever been on a ship, or even seen the ocean. But now they were standing on the deck, and the American shore disappeared in the distance, and there was nothing all around but sea water. And the two boys just stood there, watching the waves and trying to get adjusted.

Finally one said to the other, "Man, that sure is a heap of ocean." And the other looked, and thought, and thought some more, and then he said, "Man, it sure is – and man, that's just the *top* of it."

I feel much the same way about this subject of management. It sure is a heap of ocean, broad and deep. The part I want to look at especially tonight has to do with the managers of tomorrow – the stimulating and fostering of personal growth so that more people will become first-rate managers. This one part is quite big enough to make me feel very humble in the effort. I did not say "the management of people" or "management development." Those words imply that we can somehow bring about growth by direction, and I do not think we can do that. Certainly we can impart knowledge and help people acquire skills. But growth is something beyond those things.

Recently a friend told me of a father who was taking his son on a visit to Williamsburg, Va. As they walked through a certain historic house, the father said, "This is where the Jefferson of history was born."

The son, a bright student who knew the facts, said, "Dad, what's the matter with you? You know that Jefferson was born on the other side of the state near Monticello."

"Yes, I know," his father replied. "That's where he came into the world. But this was the home of George Wythe, with whom Jefferson studied law. Here lived the man who helped Jefferson grow to greatness, not by marking out his path for him, but by maintaining the climate that encouraged great qualities to emerge. Jefferson was a bright man by inheritance. That part of him was born near Monticello. And with that part alone he probably would have been well known among his contemporaries. But the qualities of greatness that *we* know him for were born here."

I doubt that anyone really understands the process of human growth. But I think that among other things, growth is a matter of goals to grow *toward;* of room to grow *in;* of risks and responsibilties to grow *on;* and of inspiring and nourishing a deep desire *to keep on growing.* These are the things I should like to talk about most.

First, however, just a few comments on the aims of management generally. What should our goals be as they relate to the owners of the business – to the public – and to employees?

Our duty to the owners as I see it is to keep the businesses we manage in a healthy state – as to their products and services, and financially; expanding as the nation's needs expand – ever improving our products – and financing this progress largely out of earnings. This means making enough profit so that expansion will not depend mainly on fresh supplies of outside capital. I say this with full realization that the business in which I have been a manager (a business under public regulation) more than most others has needed outside capital to expand. And I say it because I am quite convinced that for any business, regulated or nonregulated, ability to expand out of earnings is the strongest incentive to progress; it gives the greatest encouragement to innovation and the taking of new risks, increases the flow of capital to new enterprises, and in the long run results in the greatest production of goods and services of high quality at lowest price.

What should management strive to provide for the people in the organization? I would say interest, opportunity for individual growth, and real incentives in their work; with these, wages and working conditions that will improve standards of living. These goals are really pretty clear, though methods and speed of accomplishment are troublesome factors. Obviously they are all best attained by good and ample profit, and become very difficult by the lack of it.

I also think such aims with respect to owners and employees help management to discharge its proper obligation to the public. This, as often stated, is to provide ever-improving goods and services, and new goods and new services, at prices which continually bring the enjoyment of additional goods and services within the reach of more and more people.

As a sort of footnote, what about the managers who achieve all this – if they can? What is their reward?

Halsman, N. Y.

Cleo F. Craig . . .
principal speaker at Sloan convocation banquet

For some it is doubtless in money. But my observation is that most men at the top do not actually measure their reward that way, and I imagine those who do find less satisfaction than they may have hoped for.

The real satisfaction is rather in knowing you have done everything you were capable of doing; and the most important part of this, to my notion, is in what you have done to inspire other managers to come forward – not following your path, but walking firmly in their own.

Management's progress in the last generation or so has been materially aided by some important changes in the conception and practice of the art of management. I'll mention three.

The first is the widening and deepening of the sense of trusteeship. The ever-broadening base of ownership has had much to do with this. The very size to which many businesses have grown has had a lot to do with it. So has the obligation on industry to help win wars and help preserve the peace. And public opinion freely expressed has had tremendous influence. As the managers of business have come to know better how much their decisions affect all their fellow citizens, they have gained immeasurably in understanding their responsibilities to the public and to employees, as well as to the owners.

A second aspect of progress is that managers have been increasingly alert to foster and encourage technical advances. I know management did not invent invention, nor is science management's handmaiden. But more and more managers have had the wit to see that new knowledge and new processes continually open the way to new markets. They have visualized new products and services, and boldly spent the money for the research and technology required to achieve them. I cannot prove it but I would guess there have been more industrial innovations of all kinds in the last generation than in any comparable period before. And though often the costs were high and the risks were great, managements have been willing to accept them, to the great advantage of all concerned.

Finally, top managers have learned to decentralize and distribute authority to a greater degree than ever before.

With the increasing size of business necessary in many activities to serve a national market, this was a "must." I am sure there is more of it still to do, but the results so far have been good. Regardless of technical progress, the public would not have been nearly as well served if there had not been a general advance in the art of organizing large numbers of people with various skills in different locations to achieve a common end. And wider and wider delegation of authority has been the key to this.

This brings me to the present and the outlook before us. To put it mildly, it's a formidable outlook. The opportunities are greater than ever, but so are the problems. At least it seems that way to me.

We have a population growing by leaps and bounds, and almost certain to keep growing rapidly for years to come.

We have the prospect of increasing scarcities of raw materials in this country. The prosperity of the United States may well depend on our success in buying these raw materials from other countries, which means of course selling our goods to them. In this field of international trade, the arts of management and statesmanship are interdependent and must complement each other.

We shall see big organizations growing even bigger to serve a bigger nation. The welfare of every community, and of millions of small businesses, will be even more intimately bound up with the social behavior of big business – and the success of larger businesses will inevitably depend on how well they meet their social obligations.

We shall have a faster rate of technological change than ever before. This will profoundly alter the composition of the working force. The impact will not be on productive processes alone, but on the forms and types of industrial organization – on marketing and distribution – and on the very kinds of goods and services that industry provides.

We have the present fact of inflation, and the prospect of more. This is the biggest immediate problem facing the whole country.

Last but not least, we have the vast extension of government controls; regulation in countless forms; taxes that modify almost every phase of business practice. I do not think this is going to change. We have big government now and we are going to keep on having it. It will take constant initiative, and patient and tireless effort, to get and keep understanding of business realities by the people in government who have the authority to control, but who are not responsible for the success of what they control.

These then are some of the prospects. They add up to a world of social, political, economic, and techni-

cal change in which managing anything is bound to be more difficult.

But I would say: How fortunate it is that such perplexing problems lie before us. For this is the environment that will surely produce strong, capable individuals; managements of outstanding competence. Our job as managers today is to do everything we can to help the oncoming talent get its greatest opportunities for growth. In the past we have had many more potential Jeffersons than we ever brought forward; we have plenty of them now; our plain duty is to create the climate in which they will flourish.

I am sure we are all conscious of this, and better yet, we are working at it. For instance, in recent years business has come to a keener understanding of the need for education. We comb the colleges in strenuous competition for the best talent. We send people to school and we organize schools of our own. We conduct seminars and discuss cases. We attack problem after problem after problem with course after course after course. I have only a few things to say about this.

To begin with, as the social and economic structure becomes more and more complex, and the behavior of each part increasingly affects the behavior of others, then it is quite clear to me that people in management must extend their knowledge and broaden their thinking. Exposure to different points of view is essential. And courses and case discussions are worth a great deal when they light up men's minds and cause them to burn brightly.

But valuable as all this may be, we cannot expect too much from it. All the management training and development programs from here to Hong Kong will never of themselves make a man a top-notch manager. Furthermore, this schooling can give both the trainee and his bosses a false assurance that his development is taken care of.

What then can we do? What process, what conditions, what climate will cause more and better managers to emerge in the future? I have no simple answer. I doubt there is one. But I feel rather like the native in the Deep South who was asked by a tourist, "How do I get to Charleston?" He thought the question over carefully and then he said, "Well, suh, you begins from heah." So we begin with what we have to work with.

People in business grow mainly from the jobs they are assigned to do and the way they do them. Delegation provides the route for men to grow to higher responsibilities. But to recognize this is just the *first* step in encouraging a man to grow. The underlying question is, how do we look at the individual? Do we say, "Here is a person we intend to guide according to *our* ideas of how he should grow?" Or do we say rather, as George Wythe must have said to himself when he looked at Jefferson, "We want the conditions of this person's work to be such that he will surely become everything he can be?"

The difference is fundamental. If we try to get people to become something we should like them to be, then, whether we mean to or not, we are limiting their possibilities right from the start. Only when we work to remove all limitations to growth can we expect that the exceptional qualities of able men will emerge to the full, and in ways that no one, including themselves, could have foreseen.

I shall give a simple analogy. No one can tell a scientist what it is that he must discover. We may ask him to attack a specific problem, yes, but the solution can never be prescribed. It is impossible to order up an invention. All we can do is depend on the scientist to discover what he can – to achieve all he is capable of achieving. I think we have to give managers and potential managers room to grow in, in much the same way that we give a scientist room to discover whatever it is possible for him to find.

For example, I think we should get young people into the situation of having to make real decisions early in their careers. And I mean hard decisions. After all, the necessity to choose between different courses of action is the essence of business discipline. We can expect quite a few mistakes but they have two great advantages. First, the people who make the mistakes will learn more from them than from all their successes. Second, making mistakes early is a good vaccination against making more expensive ones later.

Another essential I am sure is to watch incentives carefully. As exceptional men emerge, the rewards they receive and the challenges and opportunities they see ahead must be such as to keep them wanting to grow. If we level out rewards we shall level out motives and abilities too – and I mean level them down.

Still another way to give people room is to give them experience in different kinds of jobs. I know there is nothing new about this, and I am aware of the pitfalls. For instance, a transfer that does not add something – and I would think quite a lot – to the challenge a man feels, can hardly contribute to his growth. Also I would not affirm that in the telephone business (for example) we have never made the mistake of moving people too often, so that it was difficult for them to master some of their assignments.

But when the process is rightly used, so that people see it as offering them new opportunity to grow, I think it contributes a great deal to their all-round ability. Of course I am not talking about picking a man on a hunch and sending him on a rotational tour of the business while everybody else watches and mutters. I am talking about a real test every time on a real job every time. Also it seems to me there is this further advantage: A man on the way up needs to have the organization with him. And I sincerely believe that the man who can prove himself in job after job is the man the organization would like to have lead them.

These, then, are a few of the things we might do to encourage men in their desire to grow – to become all they are capable of becoming. But again let me emphasize that the first need is always for us to accept, believe, and act on the basic principle that a man's growth must be *his*, and not something to be fashioned according to another man's ideas of what it ought to be. Once we proceed on this basis, and only then, we can provide the indispensable favorable climate which really inspires men to grow and keep growing.

(*Concluded on page 434*)

Financial Forces in Industrial Growth

Can we achieve higher standards of national security, living, economic growth, and social capital formation, without running the risk of inflation or depression?

by ELI SHAPIRO

My remarks at this convocation, unlike all Gaul, will be divided into four parts. These parts, in a sense, mirror the objectives and philosophy of the educational mission of the School of Industrial Management.

First, I want to discuss the principles underlying the financing of capital formation, with particular reference to how the process affects economic activity and, in turn, is affected by the manner in which economic activity is conducted in our country.

Second, I want to review the history of business financing over the past quarter century in order to understand the relationship of the past to the present and particularly to stress the responsiveness of the financial machinery to underlying changes in the political, social, and economic environment in our society.

Third, I want to explore the direction of economic activity in the future in order to discern the most probable forms of business financing that managements must plan for in the exercise of their leadership function in guiding the destiny of their businesses.

Fourth, and finally, I hope to point out in broad strokes the nature of the financial adjustments as well as the objectives that managements ought to be thinking about for the future in the light of the probable directions in business financing within the next decade.

Principles Underlying Financing of Capital Formation

Private saving can be utilized to acquire many different assets. Private saving does not imply private investment. But, the ways in which individuals and firms hold their assets can have a tremendous influence on the level of private investment. For, expenditures on private investment require, among other things, an adequate amount of funds in the hands of individuals making investment decisions. And if, to use an extreme example, all savers are seeking to channel their assets into cash accounts, the lower will be the available supply of funds for investment purposes. If we seek a sustained high level of private domestic investment, we must see that there is an adequate flow of funds to finance such purposes.

Saving may be made available for private investment in a variety of ways. Business enterprises may employ their retained earnings directly to increase their holdings of fixed and working capital. Individuals may likewise use their saving to build up their capital goods, as when the proprietor adds to his plant or equipment or the farmer employs his saving to finance improvements on the farm or a person builds a home. Individuals may make their saving available to business enterprises directly by lending money or by buying shares of newly issued stock in these companies. Individuals may also place their funds in financial institutions such as banks and life insurance companies, thereby enabling these institutions to invest these funds with business enterprises.

It is the role of our capital markets to establish the cost of funds and to allocate these funds into uses which promise the greatest returns given the required safety. Individual users of funds who offer new securities have the alternative of selling either debt claims or equity interests. From the standpoint of both the supplier and user of funds, there are risks inherent in both forms of financing, for there is no capital in any form which is not subject to some degree of risk.

If investments are to be made, some individuals or institutions must be willing to bear the risk, must be offered sufficient inducement, and must command sufficient assets to be able to bear the risk. As between investors, contractual forms have evolved which permit the shifting of individual business risks from one investor to another.

The private financial structure consists of equity and debt. Equity refers to the total nondebt (owner) component of the capital structure and consists of the "capital" value of ownership shares (stock) plus surplus and reserves representing claims to the assets and income of business enterprises after creditors' claims are satisfied. Thus, the private physical property of the country is represented, in part, by fixed dollar obligations, and the remainder, by equity (or ownership interest).

In the main, the objectives of averting inflation and depression probably represent the hopes and aspirations of most members of our society — if discussed in the abstract. But, when we get to discuss particular policies, there is an understandable but nonetheless disheartening support of specific programs by interested parties which, when aggregated, lead to a social goal quite inconsistent with the basic stability objectives mentioned above.

We now stand at the threshold of an era in which there is widespread belief that our future economic growth will be even greater than was our past. We

want high standards of living and we want more leisure. We want high levels of private capital formation to provide economic growth. We want high levels of national security outlays to insure our ability to contain the Russians in a cold war and to enable us to withstand attack should the world situation deteriorate. We want social capital formation on a grand scale. Moreover, we purport to desire to avert inflation and depressions. Can we get all of these things?

The neoclassical view on this matter was that an increase in the supply of saving stimulated capital formation by causing the rate of interest to fall, while the willingness to save effectively released resources which were necessary to permit the production of capital goods to take place.

For a relatively short span of years – the twenties in England and the thirties in the United States – a new view appeared. Savings need not finance investment but could go into hoards. Thus, unemployment would exist. Given unemployment, capital formation could take place without reducing consumption (or saving) since the capital goods production could be obtained by absorbing otherwise unemployed resources (both men and material).

While this point of view may have had merit for the aforementioned periods, the longer view of economic history lends credence to the neoclassical position which – to restate it in another way – is that consumption and investment are alternate uses of income. Given the present high levels of employment and income, if we want investment we must save – or abstain from consuming – providing, of course, that we are serious in our desire to avoid inflation. Put it yet another way, given high levels of employment we cannot have our cake (economic progress through capital formation) and eat it (do not save).

In common with many others, I believe an improvement in our understanding of the financial system is eminently desirable. Precisely what form of investigation is necessary to accomplish this objective is now being debated in heated fashion. One thing stands out in my opinion. Regardless of the form of the investigation of our financial system and independent of the findings, the simple arithmetic of capital formation is so far removed from understanding by the public that little progress in changing the financial machinery can be looked for as a result of such an investigation. What is called for at once is a program designed to remove much of the mystery from the capital formation process. An improvement in society's understanding of this process should result in more enlightened views of the costs implicit in attaining the objectives we have laid down for ourselves in the future.

A Quarter of a Century of Corporate Financing

It is desirable to understand the course and direction of private investment during the 25 years ending in 1956 – a period which includes a decade of depression, six years of war-induced prosperity as well as the postwar period.

THE DEPRESSION AND WAR YEARS

During 1929–1939, the country experienced a low volume of investment in plant, equipment, and inventories. The net stock of plant and equipment of all nonfinancial business declined. Figures reported by the Machinery and Allied Products Institute indicate that the net stock of plant and equipment in the United States fell from roughly $180 billion in 1929 to $160 billion at the end of 1939 (in 1955 prices).[1]

The impact of the war upon business finance was that it minimized business' needs for funds on fixed and working capital account. The attack on Pearl Harbor and our entry into World War II made tremendous demands upon our resources both industrial and human as the United States shifted to a war footing designed to maximize the output of goods and services needed for the successful prosecution of the war. The material allocation system that was introduced to insure an adequate flow of resources into war and war related industries permitted few resources to be made available for private investment in plant and equipment.

By the end of 1945, the net stock of plant and equipment (in 1955 prices) was roughly $161 billion, compared to $160 billion (in 1955 prices) at the end of 1939. The 20 per cent hike in gross private national product from 1941 through 1945 (in constant 1955 dollars) was due mainly to a more intensive use of existing facilities rather than to any proportionate increase in the physical productive facilities of the country. The capital-output ratio fell from 2.06 at the end of 1939 to 1.42 at the end of 1945 (in 1955 prices).[2]

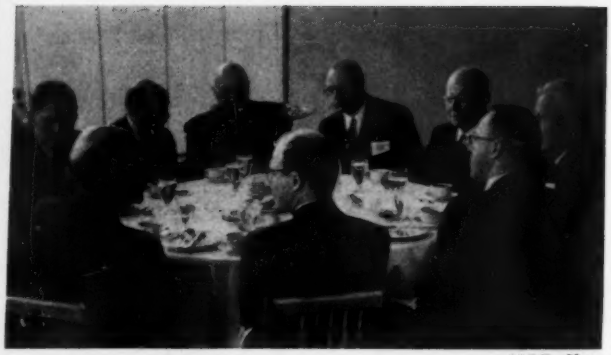
At the same time, an inventory control system was imposed. With inventories frozen and sales volume rising sharply, the system brought about an extremely low ratio of inventories to sales compared to earlier experience. This averted an increase in business' need

[1]Machinery and Allied Products Institute, "Capital Goods Review," Number 23 (August, 1955), and mimeographed tables supplied by the Institute.

[2]The capital-output ratio was derived from figures on the gross stock of plant and equipment in 1955 prices supplied by the Machinery and Allied Products Institute. See Footnote 1. The denominator is the gross national private product consisting of gross national product in 1955 dollars minus compensation to government employees.

M.I.T. Photo

Under the seal of the Institute, Eli Shapiro, Associate Dean of the School of Industrial Management, and Professor of Finance, addresses distinguished guests in Rockwell Cage during the luncheon program of the convocation. The event commemorated the fifth anniversary of the founding of M.I.T.'s School of Industrial Management.



M.I.T. Photo

A group participates in informal discussion during the luncheon in Rockwell Cage, preceding the afternoon panel on "The Evolving Role of the Corporate Director," scheduled to be held in Kresge Auditorium as part of the Sloan Convocation program.

for funds to build up this component of gross working capital which normally is experienced in periods of rising sales.

At the end of the war, nonfinancial corporations were characterized by an unprecedented volume of liquidity. Their holdings of cash and government securities amounted to approximately $43 billion at the end of 1945 and were practically equal to the outstanding short-term corporate indebtedness. While these corporations were extremely liquid when judged by historical standards, they were faced with a great need for funds to finance the replacement of war-worn productive facilities with new physical plant and equipment. Corporations also needed to augment physical facilities to handle the enlarged volume of economic activity that characterized the postwar period. Funds were also needed to increase working capital.

THE POSTWAR DECADE

The average annual use of funds by corporations in the postwar decade amounted to approximately $31 billion. Of this, roughly two-thirds was used to acquire plant and equipment. The remaining one-third was needed to build up the other asset accounts. Roughly $4.5 billion per annum was required to build up the book value of inventories and another $5.5 billion was needed annually to increase the receivables account of corporations.

It is noteworthy that the average annual outlay for new plant and equipment in the postwar decade amounted to nearly four times as large a figure as that for the immediate prewar years and more than triple the figure for the 1920's (all in current prices).

The outlays on plant, equipment, inventory, and receivables were both stimulated and, in large part, financed by the high postwar level of corporate profits and depreciation charges. Annually, about 60 per cent of the need for funds was obtained from retained profits and the depreciation accounts. Net new security issues amounted to roughly $5.6 billion per year with the bond portion dominating; net new equity issues averaged $2 billion annually while net new bond issues amounted to $3.6 billion annually. Mortgage loans provided $1.0 billion a year, and bank loans accounted for $1.8 billion.

These averages obscure trends over the period and cyclical variations in the pattern of demands made upon the capital market. Thus, long-term funds — security issues plus mortgage loans — showed a continual rise over the period. When the long-term sources fell short of total needs for funds generated by plant, equipment and inventory outlays, bank borrowing was utilized. When long-term fund accretions were in excess of outlays for fixed assets and inventory, bank borrowing was repaid and/or liquid assets were accumulated.

The relative cost of short-term and long-term funds obviously affected this pattern. However, comparison of the relative costs of these funds was not the sole explanation of the phenomenon. Corporate managements appeared to follow a few rules about balance between short- and long-term funds which affected the sources of funds they sought. In the main, these rules relate long-term sources to long-term uses.[3] Because of the almost uninterrupted growth in fixed assets in the postwar decade and the need for augmenting the "permanent" working capital of business after 1945, corporations chose continually to raise long-term funds over the period under examination.[4] When these long sources exceeded immediate needs, short-term debt was retired or liquid asset accumulations were accelerated.

Increasing dividend payouts over the period and the volatility of profits after tax are important clues to the pattern of demands made upon the capital market to enable corporations to finance their investment plans. Increasing dividend payout ratios with profits constant would obviously result in reduced internal flows of funds. An increase in dividend payments at a time when corporate profits decline and capital outlays remain constant (or increase) clearly results in increased reliance upon external sources of funds.[5]

While common stock was a small portion of total sources of funds, its importance increases over the period. From less than 25 per cent of total external sources in the earlier half of the decade, common stock issues grew in volume to provide about one-third of total external sources in the latter five years. The proportion of common stock to total external sources of funds rose as stock yields declined.

Another interesting development in the postwar decade was the relatively small share of preferred stock financing. From the point of view of the issuing corporation, preferred stock financing had none of of the virtues of debt financing since preferred stock dividends were not deductible in computing taxable income while interest on debt was deductible. Thus, a lessening in the relative importance of preferred shares in new stock financing is observed.

[3]While this contention is difficult to prove, discussion with corporate treasurers tends to confirm this proposition. Needless to say, conformity to this rule increases as spreads between long- and short-term interest rates narrow.

[4]Corporation finance books often refer to "normal" working capital which is that portion of gross working capital permanently employed in the firm.

[5]This argument assumes no reduction in liquid asset holdings.

As a result of the manner of business financing in the postwar decade, a number of developments stand out.

A. One of these is the change in outstanding debt. Total debt in the United States rose from $380 billion at the end of 1945 to $600 billion at the end of 1955. Falling at the beginning of the decade and rising in the latter years, the public debt stood at the same level in 1955 as it did at the end of World War II.

Unlike the previous three decades, the period under examination was characterized by a sharp decline in the ratio of public to private debt. This is explained almost exclusively by the sharp rise in private debt after 1945. Public debt outstanding exceeded the private debt outstanding in 1942 and continued to exceed the latter until 1951 when private debt outstanding exceeded the public debt. Private debt continued to increase for each year thereafter. At the end of 1945, private noncorporate debt (including debt of unincorporated business units, real estate mortgage debt of individuals and consumer debt) accounted for 46 per cent of the private debt outstanding. In the succeeding years of the postwar decade, private noncorporate debt more than tripled while total corporate debt more than doubled so that noncorporate private debt accounted for roughly 55 per cent of all private debt outstanding. The principal factor behind the rise in private noncorporate debt was the very sharp increase in mortgage debt outstanding.

B. Another development of postwar financing was the change in corporate bonds outstanding. The volume of bonds outstanding for all nonfinancial corporations increased from $23.4 billion at the end of 1945 to approximately $53.7 billion at the end of 1955, a rise of roughly 130 per cent. The above changes in corporate bonds outstanding were in marked contrast with the 1920's when all corporate bonds outstanding increased by about 35 per cent.

C. Still another development was the change in corporate liquidity. By almost any other test than the current ratio, the liquidity position of corporations has deteriorated. The ratios of cash to current liabilities, cash to net working capital, cash and governments to current liabilities, and cash and governments to net working capital all fell steadily throughout the decade, reaching their lows in 1956.

Indeed, by 1956 there is at least the suggestion that the decline in the liquidity position of corporations may impair their ability to carry out intended capital outlay programs. A fall in corporate profits, if associated with enlarged dividend payments and no decline in capital outlays, would suggest tightening of internal fund flows.

D. The last development to be discussed is the change in institutional holdings of corporate securities. Throughout much of the decade, a great deal of attention has been given to the flow of funds into corporate securities through the agency of financial institutions. Our data suggest the dominant position of financial institutions in the market for corporate securities in the postwar period.

There has been a dramatic shift in the composition of the bond market. At the end of 1938 there were approximately $46.0 billion of corporate bonds outstanding. The consumer and rest of the world sector accounted for about 65 per cent of these bonds; life insurance companies held about 17 per cent; the banking system's holdings came to 10 per cent.

M.I.T. Photo

Pictured above is J. A. Stratton, '23, Chancellor, who presided at the luncheon of the Convocation of the School of Industrial Management which was held in Rockwell Cage on April 9. At left, E. P. Brooks, '17, Dean of the School, may be seen, and, at right is Professor Eli Shapiro, Associate Dean of the School.

At the end of 1955 the consumer and rest of the world sector held only 20 per cent of the $73.0 billion of corporate bonds outstanding. Holdings of life insurance companies accounted for more than 50 per cent of the total. Two other institutions whose bond holdings were negligible in 1938 call for attention. State and local government retirement systems increased their holdings of corporate bonds significantly. This is true also for holdings of self-administered pension funds. Judged by the absolute amount of their holdings, life insurance companies are the dominant institution in the corporate bond market today. This status is a product of less than 20 years.

Approximately $2.8 billion of net new issues of preferred shares came into the market in the postwar period. Since total institutional holdings of preferred shares rose nearly $4.0 billion, there was a substantial sale of preferred shares by individuals during this period. Net issues of common shares amounting to $18.0 billion were put on the market during the period from 1946–1954. Over this same period some $15.0 billion were acquired by financial institutions. The large acquisitions of common stock were found in the pension funds, nonprofit organizations, investment companies and life insurance companies.

Direction of Economic Activity in Future

Let us look into the future. Economic projections are essentially in the alchemy stage. Yet, we do need some measure, however rough, of the probable course of economic activity and the financial implications implicit in such a projection .

In order to handle this problem I shall use the projection of economic activity for 1965 that was developed by the Joint Committee on the Economic Report in its "Potential Economic Growth of the United States During the Next Decade." These figures generally represent the consensus of opinion on gross national product projections.

Using 1955 dollars and this, of course, assumes no inflation over the decade, the Joint Committee projection entails a rise in the gross national product from $375 billion in 1953 to $550 billion in 1965. This amounts to a 3.2 per cent per annum increase in the gross national product over the period. The 3.2 per cent annual increase in the gross national product is distributed as follows: Consumer expenditures rise by 3.5 per cent per annum; gross private capital formation rises by 4.2 per cent per annum; government expenditures rise by 1.1 per cent annually.

The annual per capita increase in real gross national product is 1.8 per cent – roughly identical with the average rate of increase over the last 75 years. A 1.4 per cent annual increase in civilian employment is offset in part by a 0.8 per cent annual decrease in hours per worker. Thus, the Joint Committee report assumes a net increase of 0.6 per cent per annum in man hours put in. Output per man hour is projected at a 2.5 per cent annual increase, based on the assumption of a high level of investment in plant and equipment and assumed increases in technological know-how.

The proportion of gross private capital formation to gross national product increases from 14 per cent in 1953 to 15 per cent in 1965. Net capital formation rises from 6.6 per cent of net national product in 1953 to 6.8 per cent of net national product in 1965.

A high level of private capital formation and a low rate of saving – 6 per cent of disposable income – is assumed. The Joint Committee's projection involves a high level of investment and, therefore, a high level of financing need. It also is a model which involves a low level of saving which should make for financing difficulties. It is compensated for in part by the assumption of balance in the Federal government's budget and state and local government deficits requiring financing at about the levels now prevailing. The increase in net capital formation of $11 billion in 1953 prices is assumed to be financed by an increase of over $3 billion in personal savings, an increase of some $2 billion in corporate savings, and a reduction in government deficits of $5 billion.

If we turn to the corporate sector, we find a substantial need for funds primarily to finance the plant and equipment outlays contemplated. Funds generated internally by business out of retained profits and depreciation and depletion will continue to supply the bulk of the needs of corporations for financing – over two-thirds of total needs. Net new issues of securities may amount to as much as $7.0 billion with debt issues dominating the total. This sum is not perceptibly higher in absolute amount than most of the postwar years in which high levels of plant and equipment outlays were experienced.

Given this projection of economic activity in the decade ahead, I am inclined to believe that interest rates will be somewhat lower than those currently prevailing. This is not to say that we will return to the level of interest rates that prevailed in the decade of the 1940's. Rather, I am inclined to believe that the average of rates for the first five years of the 1950's is the most reasonable fit for the projection of economic activity in the decade ending 1965 as enumerated above.

Financial Adjustments and Objectives of Management

What are the implications of this projection of economic activity for financial management?

Capital management is that aspect of top management policy which is concerned with a systematic and correct basis for directing funds into and through a business so as to achieve the long-run goals which a company sets for itself. Although these goals might take the form of specific policies with regard to a variety of matters, for example, size, scope of product line, market share, production methods, liability and ownership structure, each such policy is a means to an end rather than an end in itself. The single all-encompassing goal is the maximization of long-run earnings to stockholders, and capital management is directly concerned with this goal.

The postwar decade has witnessed an increasing interest, both in business and academic circles, in the development of systematic approaches to the problem of capital management. Capital budgeting, which is the formal framework in which capital management makes and expresses its decisions, has become increasingly systematic, and considerable attention is now being paid to the principles on which sound approaches to capital budgeting must rest.

There are a number of good reasons for this interest in the capital budget as a prime tool of top management policy:

(1) The collection and projection of national economic data make it feasible for business to make long-range estimates of potential markets. Such estimates, in turn, lead to long-range estimates of facilities and capital required to implement a company's own goals within these markets. Thus, the annual capital budget becomes a framework in which the future of the company is planned, and it is increasingly recognized that decisions made in a series of such budgets will ultimately determine the scope, size and profitability of the company itself.

(2) The increase of special skills and special departments within a company requires a central mechanism in which the many facets of its operation can be brought together for over-all analysis in terms of over-all goals. The capital budget provides just such a central clearing mechanism. Capital is the one element common to all departments and the process of allocating this capital is the principal device through which central management implements total company policy while leaving divisional policies to decentralized units of departments and skills.

(3) The present interest in capital budgeting and management stems not only from the fact that it is important, but from the fact that it is difficult. The task of bringing together technical, market, economic, and financial factors within a single framework so that the decisions which are made truly reflect the best interests of the company as a whole presents difficult problems not only of forecasting and estimating but also of logic and analysis.

(4) Finally, from the social point of view, business as a whole has begun to recognize the crucial impact on the economy of individual capital decisions. Just

(*Continued on page 436*)

Systems Technology and Industrial Dynamics

Modern technology makes possible a new approach to study of industrial organization and future trends

by JAY W. FORRESTER

DEAN BROOKS has given you the objectives of a management school in the M.I.T. community. I will discuss how ideas from a technical environment can be expected to influence the practice of management. I stress here the ideas from engineering and science rather than the influence of equipment. Too often, electronic data processing, as a replacement for clerical workers, is assumed to be the principal technological contribution to better management. More important will be an understanding of how to make information most useful in managing a company. We have much to learn about the relationship of information to the conduct of a business.

When we can look back over the next 20 years, the mechanizing of clerical data processing will seem but a small first step. A greater advance will be the improvement resulting from more effective use of information. The improvement will result from a better grasp of the business enterprise as a whole, and from a better understanding of how information flow and decision-making processes form an underlying foundation that determines and explains the fluctuations in finance, manufacturing, and distribution. In classical economics the emphasis has been on the interaction of money and materials. It may well be that information flow is even more significant than money flow in determining the behavior of our industrial organizations and economic system. One might be partially correct to say that information controls what will happen; money is an evidence of what has happened.

Discussing systems technology and industrial dynamics in the Kresge Auditorium is Jay W. Forrester, '45, Professor of Industrial Management at the Institute.

M.I.T. Photo

During the last decade, while electronic data-processing equipment was being developed, there have been evolving new concepts of information flow, of the relationship between information and control, and of ways to study and predict the behavior of complex systems. By the term "systems" I mean, not the paper work forms and procedures that it often means in business, but the broad interaction of how production, sales, advertising, research, cash flow, and plant construction affect one another and how the external economic environment affects the whole combination.

Management is, I believe, on the verge of a major breakthrough in developing new ways to understand the interaction between the flows of information, materials, man power, and money.

It is the task of management to understand this interaction and interpret these flows into operating decisions. To expedite these decisions, management decision making has been broken down into functional areas. Management education and management practice thereby become fragmentized. Finance, manufacturing, personnel, distribution, marketing, and accounting are too often viewed as separate skills and not as part of a unified system. Much of academic teaching consists of gathering current industrial practice and presenting it to the student as a series of unrelated subjects. Likewise, in his work in industry, the man specializes within divisions or departments where his experience perpetuates the atmosphere of unrelated compartmentalization.

Nowhere, either in formal education or in work experience, is the prospective manager given an adequate, explicit, or even intuitive framework into which to fit the parts of the whole industrial system. Only at the highest management levels do we find attention to integrating the many components of a company. The top-level manager is the man who can better perceive the whole system, its objectives, and its growth. We have a shortage of top-level managers with this over-all perspective, not because of a shortage of candidates, but because potential talent is too often suppressed by the environment, by the pres-

sures of day-by-day routine decisions in the modern organization, and by the absence of an underlying concept of how the parts of the industrial system interact with each other. Industry is becoming increasingly aware of the problem. Solutions have been sought through breaking down the scope of decisions by decentralization, and through formalized training and rotation of management personnel.

I visualize the next big step in management education as the development of a basis for fitting together the many management functions into a meaningful whole. Around this central core, specialized subjects and experience will take on more meaning. Men can be developed more rapidly. They will be able to start from a point now accessible only through long training or fortuitous experience.

The recent history of engineering provides a precedent showing one way in which management may develop in the next two decades. Since 1940 the scope of engineering has expanded in two directions. First, there has been an increasing emphasis on the basic science underlying engineering devices. The great engineering successes of the last 15 years have been achieved by men who have integrated underlying science with the practice of engineering. The effective engineer must understand the enduring fundamentals and not merely their manifestation in particular devices contemporary with the period of his college education. Second, the scope of engineering has simultaneously broadened to formally encompass the interrelationships between the separate parts of complex systems.

The importance of interrelating the separate components has grown until a special meaning has become attached to the term "systems engineering." Articles in the technical press appear under such titles as "Systems Engineering – A Growing Concept" and "Systems Engineering: Its Role in Electronics." The practice of systems engineering is not new, the widespread awareness of its importance is. Systems engineering is the formal recognition of the importance of interaction between the parts of a complete system. This interaction may be economic; it may involve the proper matching of equipment to the requirements, abilities, and limitations of people; it may involve the proper kind and timing of information flow from one part of the system to another.

Training of the manager today is in much the same state as was engineering training before 1940. So far, there has been no development of a fundamental concept explaining over-all operations; nothing to relate company organization and decisions to stability, profits, and growth. As happened in engineering, I believe management education is now ready to develop both an underlying foundation of communication and decision principles, and also an orderly basis for integrating the various company activities into one coherent system.

We need new approaches to understanding the dynamic behavior of a company. By dynamic behavior I mean the way an organization reacts to changes – changes in financial conditions, product demand, new competitive conditions, growth, technological advances, new policies, or new social responsibilities which are presented.

The behavior of business organizations under static conditions is fairly easy to grasp. But conditions are never static. There is inadequate understanding of how the company organizational structure, information flow channels, and decision-making procedures often convert small external influences into amplified oscillations within the system. For example, how often do we erroneously blame consumer demand for production changes that are actually caused by the information delays and ordering policies within the company? How often does advertising policy cause unanticipated inventory and manufacturing fluctuations? How often has an apparent seasonal demand pattern been unintentionally created by the company's marketing and inventory policies rather than by the consumers? How often is company growth hampered by an incorrect distribution of research and development man power between long range, medium range, and immediate goals?

These kinds of questions are continuously encountered by the executive. They must be answered on the basis of experience and intuitive judgment. Only now is there taking shape a basic framework that should help answer these "systems questions." By "systems questions" we mean the problems of coordinating the goals, policies, procedures, and decisions of each part of the organization to best promote the objectives of the company as a whole.

The principal technological contribution to management will, I believe, be the ideas from which a basic framework of management theory can be evolved. There are three pertinent areas that are well advanced in the technical professions – the theory of feed-back control systems, the study of decision-making processes, and the simulation of complex system behavior.

Technological Contributions to Management

Theory of Feed-back Control Systems – First, at the beginning of World War II, the theory of feedback control systems, or servomechanisms, was put on a formal and orderly basis. In a feed-back system, information and actions affect one another continuously in a closed loop. The feed-back system permits us to observe the results of our actions and continue to make corrections until the outcome is satisfactory. However, such systems can become unstable and oscillate if there are too many time delays in the closed loop or if control actions are too drastic. Conceptually, the feed-back system is of great significance in understanding our everyday experiences. As you reach for a pencil on the table, your eyes detect the discrepancy between your hand position and the pencil, thereby producing correcting signals that go to your arm muscles; as you drive a car the control loop of steering wheel-to-auto-to-street-to-eye-to-hand permits you to stay on the road.

In business, orders and inventory levels lead to decisions on manufacturing rate which permit filling orders and correcting inventory; a profitable industry attracts competitors until the profit margin is reduced to equilibrium with other economic forces; the competitive need for an improved product leads to research and engineering expenditure which produces

technological change; the need for additional capital leads to borrowing or reinvesting earnings toward company expansion. All of these are information feed-back control loops. The information feed-back process is continuous, and the new results lead to new decisions which keep the system in motion. Almost every management decision affects the situation on which the decision was based and is therefore part of a feed-back control loop.

The analysis of feed-back systems treats the use of information for the purpose of control. It helps us understand how the amount of corrective action and the time delays in interconnected systems can lead to unstable fluctuation in the controlled output. My example of driving an automobile is too perfect a system to show the important influence that the information channels have on system behavior. Industrial and economic systems have many stages and delays between decisions and the resulting actions. Automobile driving would be a better example if the structure of the information flow channels were changed. Suppose the driver were blindfolded and drove only by instructions from his front seat companion. The resulting information delay and distortion causes the erratic driving. Indeed, in business one does not have a clear view of the road ahead. The automobile feed-back system example might be still more representative of the business enterprise if the blindfolded driver could get instructions only on where he had been from a companion who could see only through the rear window.

This is not an absurd analogy. In business, as in other fields, our estimate of what will happen in the future must be based on the past and present. Feedback theory explains how the decisions, time delays, predictions of the future, and cascaded sequences of actions can produce good control or dramatically unstable operation of the whole system. In business these unstable fluctuations appear as large swings in inventories and production rates, and in business cycles.

Study of Decision-Making Processes – The second thread of our picture is the study of decision-making processes. Studying decision-making processes has been a companion to developing digital computers. Most computer applications involve automatic decision making based on predetermined rules. The digital computer, as an element in a feed-back system, forces the critical examination of the factors influencing decisions.

Under the stimulus of military necessity, weapons systems have been carefully analyzed so that digital computers might be used to speed information flow and decision making. It has been necessary to distinguish between the kinds of decisions which are best made by people and those which can better be made by machine. Success in analyzing military systems promises better understanding of decision making in our commercial and economic systems. Our industrial systems are considerably more complicated than even the most advanced military weapons systems. However, in business we have an important advantage – one can observe the company in its real life environment. An air defense system does not receive an actual real life test until it is too late for a redesign. Where business can continue to learn by trial and error, the military system can only be tested in advance by mock battles and by simulation.

Simulation of Complex System Behavior – This brings us to the simulation of large systems which is a third technical development of importance to the future of management. Simulation has here its ordinary meaning of presenting the appearance of the system under study without, in reality, being the system. Simulation is the representation of a real system and its operation by a model. In our present context, simulation means setting up, in a digital computer, the conditions which control the flow of information, money, materials, and labor within the company. On the basis of the initial description and assumptions about company operation, the computer then generates the resulting charts of financial and product movement.

A simulation study is valuable in two ways: First, it forces a careful analysis of over-all company operations, policies, long-range financial plans, productivity, profitability, communications structure, and decision-making procedures. The mere finding of the necessary and pertinent facts for a simulation study will in itself reveal useful and previously unknown information about the company. Knowledge of the pertinent, previously unavailable, facts will alone lead to improved operation. Second, when the dynamic model of company operation has been set up, graphs of company performance can be obtained quickly for many different assumed operating conditions. The effects of different factors can be separated. The dynamic behavior under changing conditions, which is almost impossible to visualize intuitively, can be quickly and easily obtained.

Simulation is being used in the design of guided missiles, for studying military tactics, for training personnel, and in engineering work. For example, in planning the development of a river basin, numbers in a digital computer represent water volumes, flow rates, electric demand, and rainfall. A few seconds of computer time can solve a day of system operation. Dams can be located and designed for an optimum compromise between the benefits from hydro-power generation, irrigation, navigation, and flood control. The problem is similar to that faced by a manager in deciding plant locations, financing, advertising, and production.

To use simulation studies will not require an extensive mathematical ability. To be sure, details of setting up a study will need experts because there are special skills required and pitfalls to be avoided. However, directing the situations to be explored, judging the assumptions, and interpreting the results will be within the ability of the type of man we now see in management schools and executive development programs. We can expect simulation of the dynamic behavior of industrial organizations to be a useful tool for the thoughtful manager of the future.

Industrial Systems

Thus far, I have suggested that the greatest contribution from technology to management education will be a basis for integrating the various aspects of

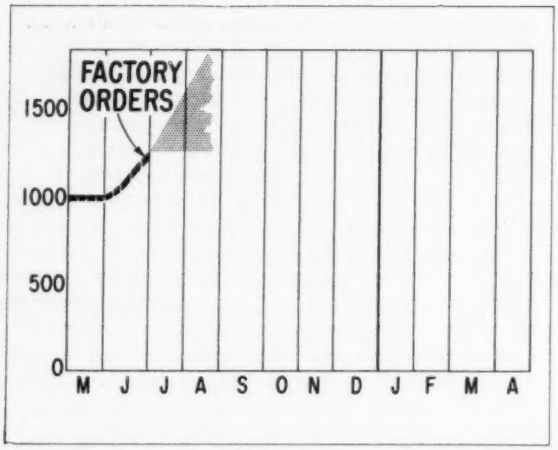


Fig. 1. Change in number of orders (heavy line) poses problem of future trends which may reasonably be expected to lie within region represented by cross-hatched area.

management into a unified "systems approach." Our capitalist type of economy and the individual company within it, each represent a feed-back system. Communication is the unifying structure that ties either a company or the economy together. Without the ability to transmit information and to ship goods we would revert immediately to an agrarian or nomadic society. The delays and distortions in communication channels cause much of the fluctuating behavior of our industrial society. The theory of control systems using information feedback, coupled with a knowledge of decision processes, can explain how information flow affects the dynamics of the whole system. The digital computer, used as a system simulator, gives us a practical tool for studying the dynamic behavior of complicated systems.

We can think of an industrial organization as having four aspects: (1) a flow of physical goods; (2) a movement of man power; (3) a flow of money; and (4) an information and decision network that ties together and interrelates the first three.

So far, this may all seem rather general and vague to you. Let's take a very simplified example of one part of a company to illustrate what I have been saying. Suppose you manufacture a durable consumer product like washing machines, and the orders received week-by-week at your factory are shown in Fig. 1. Each vertical line is a month. The chart shows orders per week. For the past six months you have been selling 1,000 units a week at a rather steady rate. Four weeks ago, at the end of May, orders received from your distributors started up as shown.

A decision must be made on future manufacturing rate. The lead time in the factory is several weeks so that production-rate decisions are made well in advance of increased output. The factory production-rate decision must depend on several considerations. If the factory warehouse inventory is not to be seriously depleted, the manufacturing rate must at least be increased to the new sales rate. Because of the factory lead time, inventory will drop during the weeks while waiting for the new, higher production level to be established; therefore, units must also be produced for inventory replacement. The production-rate decision must be based on some presumption about future sales trends. As shown by the cross-hatched area of Fig. 1, future sales might be predicted to level off at current values, or be extrapolated along an extension of the curve. Probably most predictions would lie somewhere in the shaded area. Taking the lowest and most conservative guess, that is, sales will continue at the present level, you may still wish to add temporarily to the manufacturing rate to build up inventory to a new, higher level corresponding with the new, higher sales volume. As a result, factory production rate is increased to correspond, first, with current sales; second, to replace inventory lost while the new production rate is being established; and, third, to increase inventory somewhat to correspond with the new, higher sales volume. The decision is not to increase production by the further extra amount which would correspond to extrapolating upward the current sales trend.

By the end of July we find, in Fig. 2, that the order rate has continued to rise and factory output is beginnning to increase. At the end of October, we find that orders have fallen considerably but, because of the lead time, factory output is just reaching its peak.

In Fig. 3 we see the order and factory output pattern for the 48 weeks following the initial increase in orders. Orders have gone from 1,000 units per week to 1,350 units per week in 11 weeks. In another 14 weeks orders had dropped to 900 units, later coming back up to 1,100 units per week.

Now, we are ready to ask what was happening elsewhere in the system during this interval of almost a year. What caused the large up and down swing in production? Could something have been done to achieve a more uniform production rate? Is this a seasonal fluctuation in sales which will repeat in the next year? Does the manufacturing fluctuation result from corresponding changes in the whims of the fickle consumer, or from causes that are controllable by the manufacturer?

In an ordinary situation, one might have trouble locating answers to such questions. However, the

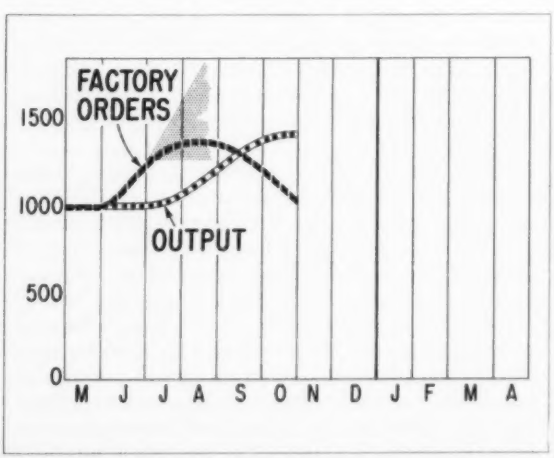


Fig. 2. Changes in orders, compared with modified production operations, show effect of lag time in correlating these two important operations of a manufacturing plant.

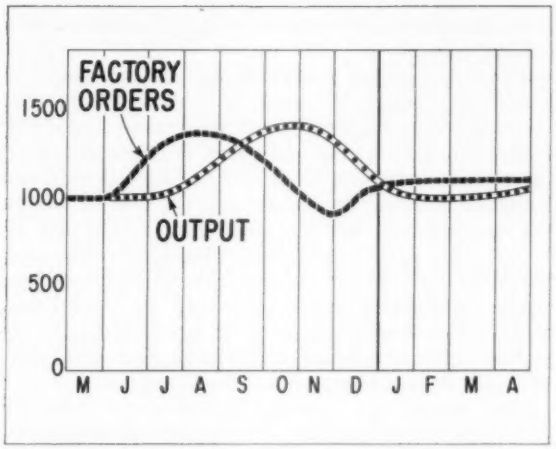


Fig. 3. Number of orders (heavy line) and factory output (dotted line) for 48 weeks show significant oscillations resulting from inability to forecast speedily and accurately.

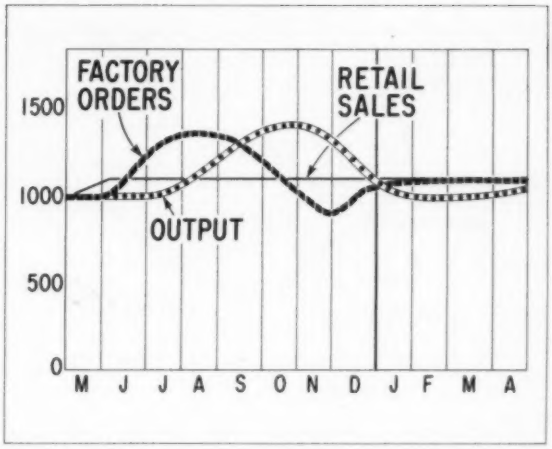


Fig. 5. Retail sales (light line) which have caused oscillations in industrial operations are seen, with hindsight, to have been of simple type.

production curve we have just seen is from a simulation study. Therefore, because we have a model of this particular factory and distribution system, we can determine the effect of changes in that system.

First, in Fig. 4 is a flow diagram of the manufacturing and distribution organization. It is a rather ordinary structure. The bottom box represents the consumers. Above this is the retail level, then the distributors or wholesalers, and at the upper left the factory and factory warehouse. The dotted lines show information flow, here consisting of orders for goods; the solid lines show the shipment of goods. Besides the organizational structure as shown, two other things are needed to describe the system adequately for our present purposes. We must know the delays in both the flow of information and in the shipment of goods, and we must have the decision criteria used for the placing of new orders by each level of the system. The average delays are shown on the diagram in weeks. Goods are delivered to the customer the week after he places his order. At the retail level, the delay averages two weeks between an actual sale and when an order is sent out to obtain a replacement. Mailing delay for the order is a week, the distributor takes a week to process the order, and delivery of the goods takes another week. Similar delays exist between the distributor and factory warehouse. The factory lead time averages eight weeks.

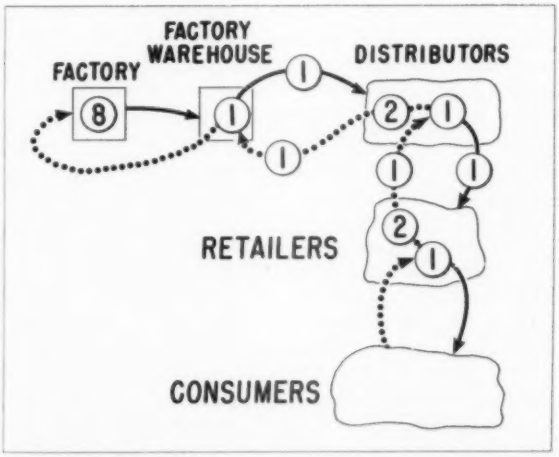


Fig. 4. Flow diagram showing the essential steps in manufacturing and distribution operations, and their interrelations in organizational structures.

The ordering criteria used at each level are the same as already discussed for the factory. No prediction of sales trends is used. Orders are placed to cover current sales rate, plus orders to replace inventory depletions that occur while waiting for replacement stock, plus orders to change the desired level of inventory as the average volume of business increases and decreases. If we then use this flow diagram, with the delays and the ordering criteria, it is possible to calculate how consumer demand changes will be propagated upward through the system. I will not take time to explain the calculation process which consists of moving, week-by-week, the shipments and orders that would flow in the system and generating the resulting inventories and production rates.

In Fig. 5 have been added the retail sales which caused the factory order fluctuations previously discussed. To test the dynamic response of the system to small disturbances, the consumer demand was increased two and a half per cent per week for four weeks and then the sales held constant thereafter at the 10 per cent level. The sales increase is delayed in reaching the factory by the delays at the retail and distributor levels. The retail sales increase is amplified at each distribution stage by the replacement of inventory depletions and the desire to increase inventory with increasing sales volume. Factory orders start to increase five weeks after the retail increase and reach a peak of 135 per cent in 15 weeks. The amplifying factors are reversible so that ordering rates fall after inventory demands are satisfied. Production drops, for a time, below that needed for the new steady demand. Nearly a year is required to dissipate the disturbance caused by this single 10 per cent demand change.

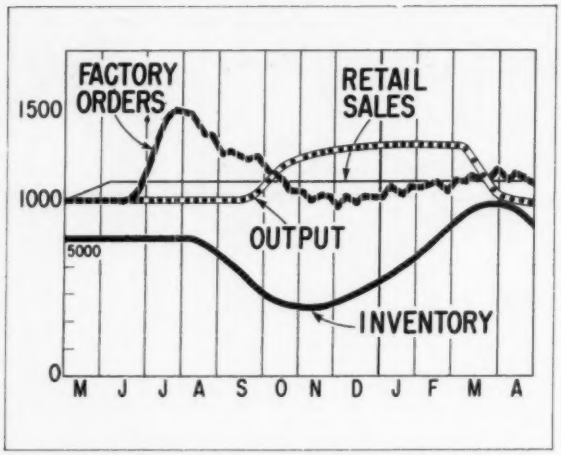


Fig. 6. Plot of orders, sales, and production of another industrial organization, and illustrating the need for rapid information processing if fluctuations are to be minimized.

The precise nature of the response is, of course, entirely dependent on the characteristics of the system being studied. Different inventory policies, a longer or shorter factory lead time, more lag in filling and shipping orders, or slower accounting and ordering departments would all affect the result. If future orders had been predicted by extrapolating the trend of past orders, the fluctuations would have been even more severe. In Fig. 6 is a chart for a slightly different distribution system. In addition to some changes in time delays, the factory capacity was assumed limited to 1,300 units per week. With these system changes, the factory output has become a differently shaped curve. Also shown is the inventory level at the factory. You will note that factory inventory drops to half and later rises to one and a quarter times its initial value. Although not shown on the graph, the total inventory, for factory, distributors, and retailers combined, varies only 10 per cent during the year.

The relationship I have shown you between retail demand and factory production is not unusual. It is common, in varying degrees, to all enterprises. In the extreme, complete production shutdowns often result from fluctuating inventories; inventories that may accumulate, not because sales of the product have stopped but because small demand variations are amplified. To many people this oscillatory behavior is rather mysterious. It is, however, a natural consequence of a feed-back control system containing certain kinds of time delays and amplification. Changes in the system would cause changes in dynamic behavior. For example, the trend toward fewer, larger, retail outlets which order directly from the manufacturer, eliminates one distribution level, changes the communication structure, and will have an important effect on system behavior. Or a different inventory policy, with air freight to back-up critical situations, might be more profitable. Or, more up-to-date information at the factory about actual retail sales would clearly be beneficial. I have heard the serious proposal made to collect sales data by leased wire from all retail outlets to help solve the problem of distribution system stability. Is this necessary, or would proper use of a sampling of sales in a few stores be sufficient? By the methods I have discussed, it can be shown how the system will respond to different inputs, changes in system structure, and modified operating policies.

The example that I have shown you can scarcely be called a complete system. It is a simplified combination of the distribution and production functions. It has information flow and a flow of goods but does not include money or labor. By adding money flow, including the factors determining the cost of carrying inventory, of changing production levels, and of losses from special inventory clearance sales, one would be able to get direct profit comparisons between various methods of operation. The model can include the restrictions imposed by available labor supply, maximum hiring and training rate, overtime, and policies regarding work force reduction.

The example has assumed that consumer demand was independent and not affected by marketing decisions in the manufacturing and distribution system. That assumption is certainly not compatible with our national confidence in the persuasiveness of advertising. If we were to include advertising and marketing in our model, consumer demand for the product of a particular business firm would no longer be independent of production and inventories in the system. The retailer may offer special price discounts if he is overstocked; the company may gear its national advertising to its sales level or to the state of inventories. If the consumer purchases are affected by these special sales and advertising, the consumer then becomes a part of the closed-loop control system. Depending on the relative timing of advertising response, the resulting effect may be either to counteract or to reinforce the oscillations we have already seen in the distribution system alone. In a simulation study, various assumptions about advertising effect could be tested. In fact, a few companies are already measuring the dynamic characteristics of advertising response which we would need for this kind of study.

To set up a dynamic model, one must adequately describe the real system which it represents. Getting the data will often be difficult. However, the kinds of information needed involve the basic characteristics of the company, such as, delays in accounting departments, mailing and shipping intervals, factory lead time, inventory maintenance rules, procedures followed in placing orders, construction time for a new plant, employee training interval, and union contract provisions. These are the same items one considers and tries to interrelate in the everyday management of a business. In a complete company model more intangible items must also be specified; for example, likelihood of results from research expenditures, future interest rates, consumer response to advertising, engineering time to develop a new product, price and wage levels, future product demand, and competitive conditions. Many of these quantities will at first be unknown; a few can be measured; some can be closely estimated; others will be guesses. Today these factors are combined intuitively, and sometimes quite effectively, but the systems approach should help reduce the margin of error. When the exact value of an operating characteristic cannot be established, one can test the system with a range

(*Continued on page 428*)

Life Sciences—M.I.T. Style

At present 117 research projects in the life sciences are in progress at M.I.T. and all show a strong influence of the basic sciences as well as of engineering

by IRWIN W. SIZER

It does not take a very careful inspection of M.I.T. to realize that it is humming with activity in the field of research in the life sciences. This comes as a surprise to many who do not ordinarily associate the name of M.I.T. with the various aspects of biology and who do not realize how ideal are the Institute's facilities for research in this area. However, the field of the life sciences is by no means a newcomer on this campus, since in actual fact it was set up as part of one of the original six courses of instruction laid out by William Barton Rogers when the Institute opened its doors in 1865 and was included in the curriculum entitled "Science and Literature." Rogers was personally very much interested in natural history and in 1871 set up a department in this area designed to prepare students "whose ulterior object is the special pursuit of geology, mineralogy, botany, zoology, or to prepare for medicine, pharmacy, or rural economy."

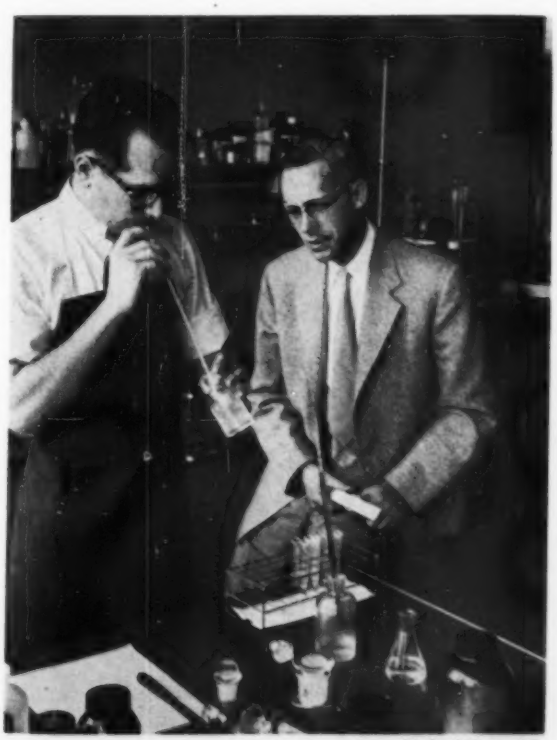
Biology was set up as a separate Department from Geology as early as 1889 under the distinguished leadership of Professor William T. Sedgwick. Since that time biology has flourished at M.I.T. especially with reference to certain applied fields, such as public health, bacteriology, sanitary engineering, and food technology. More recently the application of the physical sciences and engineering to biology has influenced the development of teaching and research in such fields as biochemistry, biophysics, physiology, and molecular biology.

Projects Related to Life Sciences

While in the early days of the life sciences at M.I.T. research was confined to the Biology Department, this is no longer the case since vigorous activity is now going on in many departments and laboratories. Of the 117 research projects in the life sciences listed in the Directory of Current Research at M.I.T., only 44 are actually being carried on in the Biology Department and 73 are being investigated in other departments of the Institute. Of all of the nonclassified research in all areas, roughly, one project out of every six is in the field of the life sciences. In most of the departments of the Institute and in many of the interdepartmental laboratories, there are one or more projects going on which are closely related to the life sciences. A brief survey of these projects will give a bird's-eye view of their nature and location as well as provide some indication of the significance to M.I.T. of research in the life sciences.

As one might expect, the major concentration, by far, of projects in the life sciences is in the Department of Biology. With the exception of Food Technology, which also has many investigations in this area, research in the life sciences is widely scattered throughout many departments and laboratories of the Institute. It might be revealing to consider briefly the types of research in the life sciences which are being pursued in the various departments and see why more than $1,000,000 is being invested each year by industry, government, and foundations in this area which has become so vital to M.I.T.

Chemical Engineering is applying thermodynamics to problems of heat exchange between human skin



Medical Press, Inc.

Biochemists of the Department of Biology study enzymes from liver which oxidize amino acids.

and various types of cloth in the hope that this investigation will make possible the design of more suitable types of clothing. Major interest in the life sciences in this Department, however, centers around the field of atomic energy. Particular emphasis is being placed on the use of radioactive isotopes in medicine, with special attention to problems of the thyroid gland and the localization of malignant tumors in the human body. The new nuclear reactor will have special facilities for biological and medical research.

The Department of Chemistry has a number of projects aimed at the synthesis of compounds with high physiological activity. These include such highly active materials as penicillin, peptides, the vitamins A and D, nitrogen analogues of the sex hormones, alkaloids, and terpenes, including those of special interest in perfumery. In addition, the Chemistry Department is interested in the fundamental mechanism of polyfunctional catalysis and its relationship to biological catalysts, the enzymes. Important applications to industry and medicine may result from these studies. Considerable work is also centered on studies of the physical chemistry of proteins and their interaction with small molecules and ions. This work has been of great significance in contributing to our understanding of the role of proteins in blood.

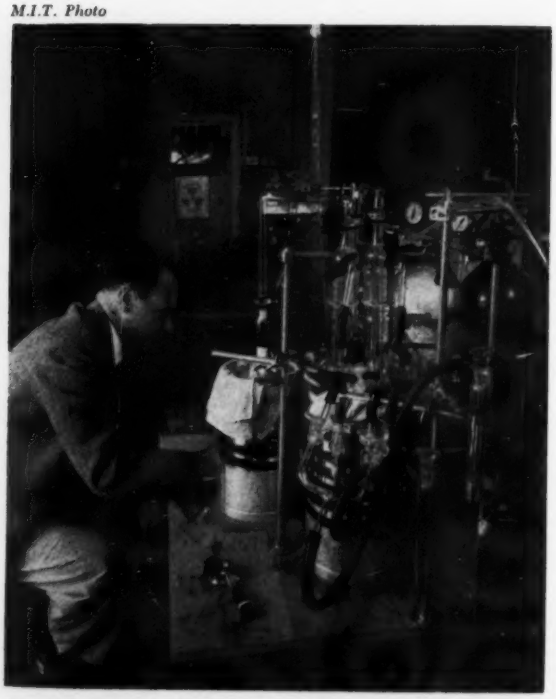
The Department of Civil and Sanitary Engineering has a number of research projects in the life sciences primarily in sanitary engineering. These problems are centered around a study of various types of wastes, including problems of decontamination of radioactive wastes and the bacterial destruction of synthetic detergents. Microbiological investigations are being carried on in the field of anaerobic sludge digestion, as well as in the area of the aerobic stabilization of organic and industrial wastes. Chemicals such as plastics and synthetic detergents pose a special disposal problem since they do not occur in nature and are not readily attacked by bacteria. In Civil Engineering there is a fascinating study in the field of structural biomechanics which has to do with the structural characteristics of the intervertebral disc of the spine and the relationship of this disc to the possible cause of lower back pain.

Investigations in the life sciences carried on by the Department of Electrical Engineering cover a wide spectrum indeed. One group of projects is primarily concerned with the field of acoustics and the application of acoustical techniques to biology and medicine. This includes the measurement of sound propagation constants with relationship to the structure of tissues and the use of focused ultrasonic sound for producing lesions in tissue. Another aspect of this investigation has to do with speech communication and a study of speech perception. These investigations are being carried on simultaneously with other aspects of communication problems. This Department has already developed an outstanding reputation in the field of the application of high-energy x-rays and electrons to biology and medicine. In this connection a most successful clinical research program on 2,000,000-volt x-ray therapy of malignant diseases is under way and this study is correlated with the effects of x-radiation on physiological and psychological functions. High-energy electrons are being used to irradiate and sterilize such biological systems as bacteria, viruses, protein, enzymes, pharmaceutical products, and food. This Department has also pioneered the field of oceanographic photography and has designed cameras capable of taking pictures of biological specimens at the bottom of the deepest ocean.

In the Communications Division of the Research Laboratory of Electronics, there are a number of problems having to do with speech. There are many facets to the researches going on in this area which encompass an analysis of languages with reference to the speech process, including physical, physiological, and social constraints to which all languages are subjected. There is also a project on speech comprehension and speech coding basic to problems which arise in information theory and its application to communications systems. As a by-product of these studies, sensory aids have been developed which involved the design of devices to be used for both visual and auditory aids. Considerable attention is being devoted to the development of the area of communications biophysics with reference to the electrical activity of the central nervous system. Computation methods are being devised for analyzing the data from nervous activity both spontaneous and evoked. In the field of neurophysiology, an investigation is being made of the relationship that exists between the electric current flow in nerve elements in the region of synapses and the modes of transmission from one nerve to the next.

As one might expect, there is a major concentration of projects in the life sciences in the Department of Food Technology. Many of these center around the use of radiant energy in a study of its effects on foods

M.I.T. Photo



Research on the sterilization of milk by irradiation during distillation is carried on in the Food Technology Department.

and living systems. Special attention has been devoted to the use of x-rays and electrons for this irradiation. Effects of radiation have been investigated on such diverse biological systems as microorganisms, amino acids, enzymes, vitamins, proteins, and foods in general, with special emphasis on the effect of irradiation on flavor, odor, and nutritional value. This Department has pioneered the field of "cold sterilization" of foods and pharmaceuticals by irradiation. A number of projects in the field of nutritional biochemistry are being carried on in this Department. These include studies on nutrition of rancid and heated fats and oils and investigations on calcium absorption and metabolism in rats, monkeys, and children using radioactive calcium. In addition, an investigation into the cause of flavor in foods is being made in an attempt to identify the flavorful components of coffee, milk, and fish.

In the Department of Geology and Geophysics special attention has been given to a study of fossils in ancient rocks and the use of radioactive tracer techniques in determining the age of the rocks and the fossils which they contain. Recent interest in oceanography will extend to a consideration of life in the sea.

The School of Industrial Management has a project on psychological measurement in which an attempt is being made to systematize and describe the methods of psychological scaling as developed in the fields of psychophysics, mental testing, aptitude measurement, and merit rating. In addition, there is a study of problem-solving groups and how such groups organize for effective problem solution. The pattern of communication structure and how it develops is being considered as a function of mental attitudes, type of task, and degree of leadership assignment.

In the Mathematics Department, in addition to its interest in cybernetics, there is work going on in the field of analytical psychodynamics. Included in this work are polynominal derivations of the error involved in the measurement of neurosensory mechanisms for application to psychology and neurology.

The Department of Metallurgy is applying flotation techniques, developed for the separation of minerals, to the separation of bacteria and other microorganisms from fermentation systems. Since one source of slime coatings on minerals is microorganisms, this Department is also studying the formation and removal of slime coatings on floating and nonfloating minerals.

For many years the Department of Physics has been interested in the biological effects of atomic energy. Special emphasis has been given to the genetic effects of atomic radiation and their significance to the present and future generations. At the present time, studies are considering the long-term effects of radio elements on humans who ingest significant amounts. In addition, the Department of Physics has been interested in the biological and medical effects of focused ultrasonic sound and their biophysical interpretation.

Projects in Industrial Medicine

It may come as a surprise to many that the Medical Department is also a center for research in the life sciences. In this Department there have been a number of projects in the field of industrial medicine, particularly with reference to medical hazards of M.I.T. research. Problems dealing with effects of radiation and radioactive chemicals have come in for a large amount of attention. Methods have been developed to detect air-borne contaminants including methyl alcohol and certain acids and organic materials. In addition, the Medical Department is co-operating in a number of the research projects in the life sciences which are being carried on in other Departments and in hospitals.

M.I.T. Photo

In the Department of Electrical Engineering this soundproof room is used for studies in acoustical biophysics.

Research at Molecular Level

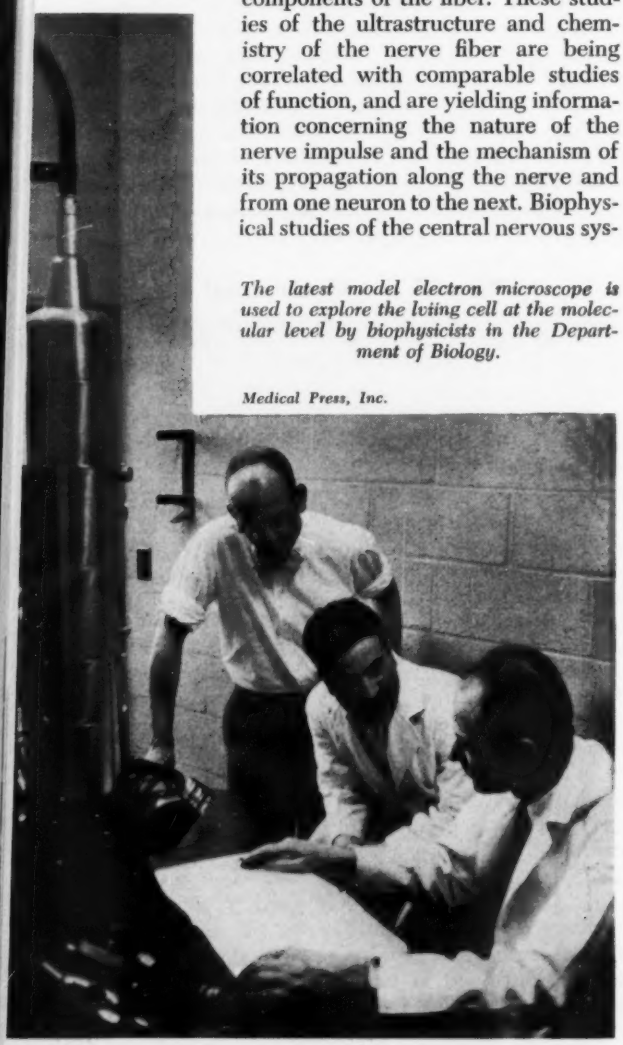
In the Biology Department there is a great concentration on research at the molecular level. Polymers of the cell are receiving particular attention, and their chemical and physical properties and origin and role in the living cell are being studied intensively by many different approaches. In these investigations the techniques of physical chemistry, x-ray crystallography, electron microscopy, enzymology, microbiology, and radioactive tracers have been especially useful in yielding information concerning these giant molecules. Of the polysaccharides, starch has received special attention, particularly with reference to the helical arrangement of its molecules as revealed by x-ray diffraction and electron microscopy. For many years interest has centered on the collagen molecule from connective tissue, and the cross-banded helical arrangement of collagen fibrils has been worked out in several laboratories of the Biology Department. More recently the dispersion of collagen molecules in aqueous solutions and the reconstitution of fibrils from such solutions has been studied. The formation of collagen in connective tissues, especially in regenerating wounds and in tissue culture, has been investigated and the role played by vitamin C in this process has been elucidated. The transformations involved in the conversion of collagen to gelatin by heat have been studied in some detail and

a homogenous parent gelatin has been isolated. All of these studies are contributing greatly to our knowledge of the synthesis and function of collagen in healthy and diseased connective tissue.

In the case of muscle, attention has centered upon the isolation of fibrous protein components, particularly paramyosin, actin, and myosin, from the muscle cell and these components have been examined with the electron microscope and the x-ray camera. From these studies the role of fibrous proteins in muscular contraction has been partially deduced. New techniques have been developed for preparing ultrathin sections of chick heart muscle at various stages of embryonic development, and examination with the electron microscope has revealed the various stages through which muscle passes during growth of the embryo.

Nerve Fiber Studies

A many-pronged attack is being made upon the nerve fiber, primarily using the giant nerve fiber of the squid. Valuable information has been obtained concerning the proteins and organic and inorganic components of the fiber. These studies of the ultrastructure and chemistry of the nerve fiber are being correlated with comparable studies of function, and are yielding information concerning the nature of the nerve impulse and the mechanism of its propagation along the nerve and from one neuron to the next. Biophysical studies of the central nervous system with special reference to communication pathways, nerve nets, and synapses between nerve fibers are being investigated with higher mammals, such as the cat. The structure and function of membranes of living cells are the subject of study in several different systems. The membrane around the nerve fiber, the myelin sheath, has been shown to be wrapped around the fiber like a jelly roll. The physical and chemical properties of such membranes are being investigated with reference to the permeability of the membrane. Radioactive tracers have given valuable information concerning the exchange of water and other chemicals across the nerve and muscle membrane. The electrical properties of such membranes have also been examined in some detail and have been related to the permeability of the membrane and the relation between membrane electrical potential and excitability. The localization and function of certain enzymes in the cell membrane with special reference to metabolism and transport of substances into and out of the cell are being correlated with other properties of the membrane.



The latest model electron microscope is used to explore the living cell at the molecular level by biophysicists in the Department of Biology.

Medical Press, Inc.

Nucleic acids have become the focal point of interest for biophysicists, biochemists, microbiologists, and geneticists. The size, shape, and helical structure of the nucleic acids have been investigated, especially with the techniques of x-ray crystallography and electron microscopy. Their formation in the cell from purines and pyrimidines in the presence of appropriate enzymes is being studied in the biochemistry laboratories primarily utilizing radioactive tracer techniques. The interest in nucleic acids from the biologist's point of view centers at the present time on their role in the viruses and the genes within the chromosomes of the cell. A genetic study of such materials is rapidly yielding information which can be correlated with that furnished by the biophysicist and biochemist. The viruses are almost ideal molecules for simultaneous study by many different disciplines and are becoming the focal point of many investigations in the Biology Department. Results applicable to medicine will doubtless be obtained from such diverse attacks.

Synthesis of Vitamins

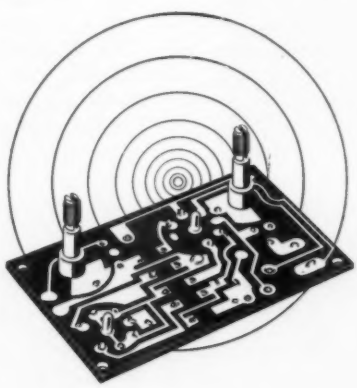
The synthesis of vitamins in bacterial cells in particular is receiving attention from the biochemists. In addition to such studies in biosynthesis, the role of vitamins as active groups of enzymes is being elucidated. Antibacterial agents are being studied particularly with reference to their mechanism of action against microorganisms and also as anticancer agents. At the basic level the role of antibiotics and other pharmaceutical agents is being investigated from the point of view of the mechanisms whereby such drugs act as specific inhibitors of certain enzyme systems. Such inhibitors are already finding major use in agriculture and medicine. Many enzymes are receiving attention in the biochemical laboratories, especially those which are involved in the metabolism of amino acids. These include the enzymes of transamination and amino and hydroxy acid oxidation. Physical chemical techniques are being applied

(*Concluded on page 440*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

"Printed circuits!" "Printed circuits!" You hear it on all sides today. And well you might. For printed circuits have so many advantages. They have compactness as compared to conventional wiring and compactness that makes possible better assembly arrangements and techniques. Numerous, time-consuming hand operations are eliminated, there are fewer rejects, shorter, less intricate assembly lines, and fewer soldering operations, as with printed circuits a single dip-soldering operation can solder all joints at once.



Revere, naturally, has been interested in printed circuits from their very inception. So Revere Research Engineers immediately went to work to perfect a copper that would meet all of the rigid requirements encountered in manufacturing printed circuits as well as those necessary to their efficient operation. Accordingly, they set up these rigid specification standards: there can be no peaks or valleys. Surface must be hard and of uniform density through and through and side to side to maintain positive conductivity throughout the circuit. Also, a hard surface permits resist to clean off easily as there are no pores to hold resist and cause trouble later when soldering. Even the most closely spaced and finest lines encountered in a printed circuit must have a sharp definition of the edges and be freer from pits, pinholes and imperfections.

Also, the copper must be free from oxidation as it comes from the mill and without lead inclusions, present a sufficiently clean surface so that fluxes will wet readily and when automatically soldered the solder coat will be uniform every time . . . free of skips or bald spots. Copper-to-laminate bond strength must be uniform and adequate. Revere Rolled Copper also shall exceed standard specifications as well as meet ASTM B5 specification for purity with a 99.9% minimum rating.

Those were the rigid standards set up by Revere Research Engineers and those are the standards met by the Revere Rolled Copper now available in unlimited quantities. Said one laminator, after using Revere Rolled Copper, "It enables us to give our customers superior copper-clad laminates that present a smoother surface (freer from pits, pinholes, and imperfections) . . . more uniform thickness without sacrifice of conductivity. The result has been, consistently satisfactory etching at better production rates."

And, because you can get all the advantages of Revere Rolled Copper at no extra cost it will pay you to make absolutely certain that you specify Revere Rolled Copper for your printed circuits when you order your boards from your laminator.

But, whether you order Rolled Copper from Revere or other materials furnished you by other manufacturers . . . the best results and the greatest satisfaction are obtained only when you take your suppliers into your confidence.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices: **230 Park Avenue, New York 17, N. Y.**

SYSTEMS TECHNOLOGY

(*Continued from page 422*)

of possible values. Sometimes the system will be found insensitive to a particular quantity and its value is thereby shown to be unimportant. If the system is highly sensitive, additional effort can be put into determining the correct value or, at the very least, the risks of not knowing become apparent.

Summary and Future

I have sketched a new, basic framework for studying the management process. It should help tie together the various separate management techniques, and help in relating the parts of a company to one another, and the company as a whole to its surrounding environment. This new framework, which will be developed in the next few years, will be based, not on the functional divisions like manufacturing, sales, accounting, and engineering, but on the underlying fundamental movements of materials, money, and labor, all tied together by the information flow and decision-making network. The essence of industrial behavior will be recognized as the way the money, materials, man power, and information networks interact to cause continuouly changing patterns within the company. This new view of the management process might be called "industrial dynamics." Industrial dynamics will treat the time-dependent interplay of changing forces acting on the company – the effect of information sources, decision criteria, time delays, and feed-back characteristics, on company success. Industrial dynamics will combine the four basic flow patterns of information, money, materials, and man power to permit an over-all "systems approach" to the industrial organization and its future trends.

There are five objectives in developing a better understanding of the interplay of forces within a company and the company's reaction to external influences:

1. Developing in the manager or management student a better intuitive feel for forces creating change, either long-range growth or short-range fluctuations;
2. Providing a unified framework within which a manager can relate his training and experience to the total system;
3. Understanding the nature and behavior of an existing organization;
4. Predicting the response of an existing system to changing external conditions;
5. Finding new forms of organization or different decision criteria to produce more successful operation.

Industrial dynamics should provide an improved basis for predicting company performance. The future of most companies for the next two, three, or even five years is already fairly well determined by the past and present forces acting on the company. The stability of trends and the resistance to change is tremendous at the level of the fundamental, controlling influences such as the company organizational structure, information channels, time delays,

(*Continued on page 430*)

Cleveland, Ohio
Chicago, Ill.
Sharon, Pa.
Melrose Park, Ill.
a "multiple source" within one company— that's NATIONAL
Phoenix, Ariz.
Indianapolis, Ind.
Many plants that operate independently or in concert—that's National. And that means orders get individual attention . . . also get all the inherent advantages of dealing with one strong company.
For engineers and young business executives on their way up, National is the name to remember—either as a source, or as a career opportunity with America's leading independent ferrous founder.
NATIONAL MALLEABLE and STEEL CASTINGS COMPANY
Established 1868 • Cleveland 6, Ohio

Dr. Lloyd P. Smith

President, Avco Research and Advanced Development Division

speaks out about AVCO . . .

AND THE RACE AMERICA MUST NOT LOSE

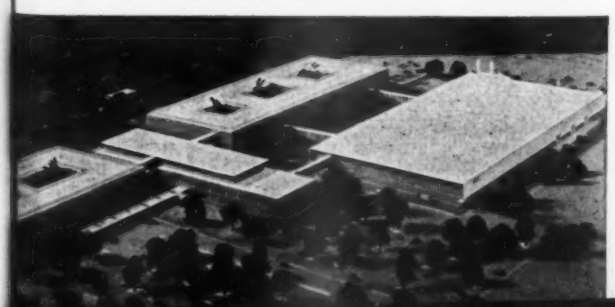
Our greatest aim is to make truly significant scientific discoveries and technical developments. Discoveries which add to our scientific knowledge. Discoveries and developments which lead to new products which can be produced for the good of mankind and insure our continued economic prosperity. Discoveries and developments which will maintain the nation's defenses strong. Most of all, to make discoveries and technical "breakthroughs" which will give our country the scientific and technical leadership and prestige which are so essential for maintaining the peace of the world. We fully realize that to attain these objectives we must win out in a great scientific game against a competent and ambitious adversary.

The Avco Research and Advanced Development Division, with its team of creative scientists and engineers, is expending great effort to reach these goals. Significant accomplishments have already been made in the physics, chemistry and gas dynamics associated with the high-altitude, hypersonic flight of missiles; the intercontinental ballistic missile re-entrance problem; missile stability; and electronics as applied to advanced radar, computers and air navigation.

New fields are under investigation and the division hopes to make technical "breakthroughs" in magnetohydrodynamics, controlled thermonuclear fusion, conversion of chemical and nuclear energy into useful work, the creation of new materials, the manned satellite, and many other areas. Some of these fields are so new that our laboratories must also be teaching centers so that young scientists and engineers who join us can learn the science and technology basic to these new fields while contributing their own creative investigations.

Lloyd P. Smith

Pictured below is our new Research Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultra-modern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.



Dr. Lloyd P. Smith

A new idea is nourished by exposure to men representing many different scientific specialities—a characteristic operating method at Avco Research and Advanced Development Division.

Avco's new research division is now offering unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers in such fields as:

SCIENCE: Aerodynamics · Electronics · Mathematics · Metallurgy · Physical Chemistry · Physics · Thermodynamics

ENGINEERING: Aeronautical · Applied Mechanics · Chemical · Electrical · Heat Transfer · Mechanical · Reliability · Flight Test

Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

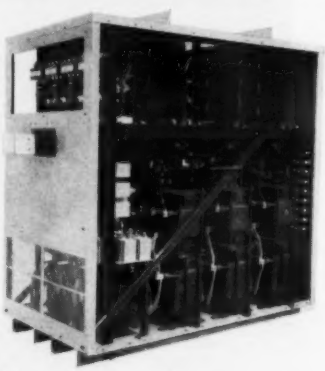
avco | **research and advanced development** division

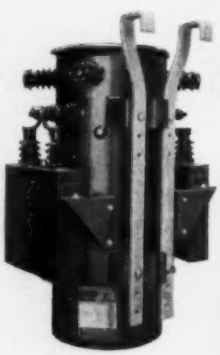
HEVI DUTY

IN STEP
with tomorrow's
stepped-up
DEMANDS

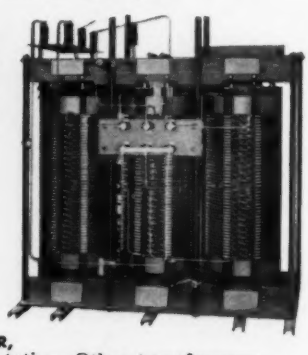
DRY TYPE TRANSFORMERS,
CONSTANT CURRENT REGULATORS
AND SATURABLE REACTORS

CONSTANT CURRENT REGULATOR used in an industrial electrochemical process.





CONSTANT CURRENT REGULATOR for street, subway and airport lighting.



DRY TYPE TRANSFORMER, 300 KVA, for unit substation. Other transformers are available from 5VA to 2000 KVA as well as Saturable Reactors from 25VA to 500 KVA.

HEVI-DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Harold E. Koch, '22, *President*
Elton E. Staples, '26, *Vice President*
Chester Meyer, '38, *Assistant Secretary*

SYSTEMS TECHNOLOGY

(*Continued from page 428*)

research and development policy, competitive position of machinery and processes, products now in the research and engineering laboratories, financial structure, basis for production and inventory decisions, advertising policy, and the distribution system. These relatively stable underlying characteristics of the company are manifested in seemingly erratic fluctuations of the more superficial quantities like inventories, sales, manufacturing rates, profits, and growth.

Now, where do we go from here? In a number of companies and institutions, one already sees a developing awareness of this area I call industrial dynamics. It has not yet coalesced into an organized field of endeavor.

Here, at the M.I.T. School of Industrial Management, we are just crystallizing our own research plans. I think industrial dynamics will become one of the principal research areas of the school, and we will develop it as rapidly as financial resources permit. In April, International Business Machines Corporation installed a 704 computer here at M.I.T., and we will use it for the simulation of industrial operations. We have a half dozen men now beginning work in formulating the structure of industrial systems; we should try to increase the number to 30 or 40 within three or four years.

It will be mandatory that we work closely with industrial companies on their real problems. This is an area which cannot be developed as an "ivory tower" study. It must represent the real processes, the political forces, the decision factors, and the actual, not the ideal, functioning of an organization of people. Perhaps the Management School should arrange to borrow a few men from industry, for a year each, to provide the industrial contact. They would help develop new ideas and take them to their companies.

In about five years I foresee the transition from research to the use of these new methods as a practical tool for company management.

These new concepts will develop more quickly than might normally be expected. They will fill a pressing need already recognized in industry. Their power will give a significant competitive advantage. Also, many companies are already developing the background skills that will be needed. Computers that are now being acquired for other purposes can be used. Operations research departments can expand into the broader management systems studies. Simulation techniques, feed-back control system theory, and analysis of decision processes are being developed in the engineering departments of many companies.

Research on broad, over-all management problems must be started within individual companies. More companies fail from poor management than from poor engineering. Yet, we have the anomaly of thorough systems studies on products and almost none on the behavior and future prospects of the company itself. Research on devices is fashionable. Research toward better management has yet to be fully appreciated.

Someone is sure to ask what these new developments mean to the manager and his place in the com-

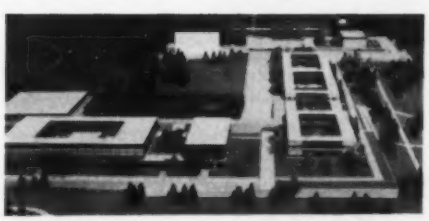
(*Concluded on page 432*)

One of the three C-E LaMont Hot Water Boilers being installed at Forbes Air Base, Topeka, Kansas.

Maybe hot-water heating doesn't sound like a new development to you. But it may be news to you that water at very high temperatures – up to 470° F and 500 pounds pressure – is coming to the fore as an advantageous method of heating large areas.

A big factor in bringing this trend about is the C-E LaMont Controlled Circulation Hot Water Boiler. Using the same principle applied by C-E in many of the country's largest utility boilers, this new boiler provides a degree of temperature control that makes it the most attractive method of heating in many cases. Examples of highly successful applications are industrial plants, large institutions, air bases and other military installations.

There are many cases, of course, where steam may still be the best choice. But here is an important point: whichever may be best for you, C-E, with its complete line of boilers of all types, can supply the equipment best suited to your particular situation. And, Combustion's wide experience is available to you and your consultants in finding the right answer. For details on C-E high-temperature water boilers, write for Catalog HCC-2.



Model of the country's newest service school, the U. S. Air Force Academy at Colorado Springs, where five C-E Hot Water Boilers will serve living, academic and service areas. Recognition of this system's advantages is shown by the fact that this same type of equipment is in service or on order for such Air Force Bases as Dover, Portsmouth, Forbes and McGuire . . . for industrial plants like Convair Astronautics Div. of General Dynamics Co., The Cross Co., Erie Mining Co. and Marquardt Aircraft Co. . . . and for such institutions as the A. E. Smith High School in Riverview, Mich.

COMBUSTION ENGINEERING

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

B-991

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

Want to weigh a whisper?

If a whisper had tensile strength . . . you could measure it delicately with the Instron Universal Tester. Yet, this versatile instrument is rugged and measures such characteristics as elongation, compression, hysteresis and elastic modulus with electronically controlled accuracy up to 10,000 pounds. For use in metals, plastics, rubber, textiles, wire, adhesives and other materials.

For facts booklet, write:

INSTRON
ENGINEERING CORPORATION
444 Hancock Street, Quincy 71, Mass.

Harold Hindman '39 II *George Burr '41 VIII*

SPECIALISTS in Pre-Fabricating PIPING

STEEL PIPE: Wrought Iron • Steel • Structural • Cast Iron • Copper-Steel • Electric Weld • Seamless • Spiral, Lap & Butt Weld • Shore-Dredge • Speed-Lay

CEMENT-ASBESTOS PIPE: For sewerage and water mains where corrosion is a problem.

ALUMINUM PIPE: In standard and light walls. All accessories stocked.

PLASTIC (PVC) PIPE

SPEED-LAY: Complete packaged PIPE SYSTEM for fast-laying, temporary and semi-permanent lines for water, compressed air and other services. Write for catalog.

VALVES, FITTINGS & FLANGES: Tube Turns • Dresser • Victaulic • Cast Iron or Steel • Forged Steel • Special Alloys • Water Main

PILING PIPE: Cast Steel and Iron Points • Plates and Shoes • Cast Steel • Malleable Iron Sleeves

COMPLETE FACILITIES for Bending, Coiling, Beveling, Swedging, Flanging, Grooving, Welding, Cutting to Sketch, and Threading to most rigid requirements. Bitumastic or Cement lining — Testing — all to Standard specifications.

ALBERT PIPE SUPPLY COMPANY, INC.

S.G. ALBERT '29 • A.E. ALBERT '56

BERRY & N. 13th St., BROOKLYN 11, N. Y.
Tel.: EVergreen 7-8100

SYSTEMS TECHNOLOGY

(*Concluded from page 430*)

pany. Is this automatic management? Do I suggest that management can be replaced by machines and formulas? The answer is, of course, emphatically to the contrary. It means that management will have additional tools. The new tools will assist, but only to the extent that the manager has the skill to use them. Just as automation requires new skills at the worker level, so will improved methods require new training and abilities at the management level.

We can expect changes in various management responsibilities. There may be a merging of certain line and staff characteristics at the top management levels. An understanding of industrial system dynamic behavior will assist in policy decisions of utmost importance to future company success and is, therefore, a top management responsibility. At the same time, systems planning is by nature a thoughtful process of weighing the past and present, not to answer the immediate decision of the moment, but to derive guiding principles for the future. The new developments will support the trend toward separation of policy making and operation with the dividing line at a lower point in the organization than at present.

The new information flow developments in the company will strongly support the movement toward decentralized management. In the past, centralized management with power concentrated at the top has resulted from an effort to get systems integration and over-all control. With a better understanding of system dynamics, we can expect improved policy formulation to encourage lowering the management level of operating decisions. Managers at the lower levels will have the training and information to see how their actions affect the over-all company goals. With this will go improved evaluation criteria for measuring the performance of a manager in such a way that his personal objectives coincide with the objectives of the whole company.

The future operating manager will be less concerned with day-by-day decisions on manufacturing schedules, advertising, inventory, and cash flow as these become more organized and systematized. Viewing the company as an integrated dynamic system is to view it as a form of a continuous process control system in which information flowing in the normal channels, and the repetitive decisions derived from this information, are handled as part of the system design. This will free more of the operating executive's time for management by exception. He can give more attention to the truly special or unusual kinds of information — the effect of external political affairs, or the inside tip on a competitor's forthcoming new model. He will also have more time for the individual aspects of human relations. Individual motivation, communication, happiness, and job satisfaction will become increasingly important to the line supervisor.

As the manager becomes less concerned with the routine, repetitive operating decisions, he will become more concerned with the unusual, the exceptions to normal operation, with innovation in products, and with the human side of enterprise.

Another M. I. T. Man-on the way

Remember when it was you standing there? How you squirmed when your father saw that one bad report card. You're glad now that he made you buckle down — grateful that you were able to go on to one of the country's finest universities.

Naturally, you want to be just as farsighted about your own son's future. So now that he's one year closer to college — wouldn't it be wise to call your Massachusetts Mutual man and discuss the best insurance plan for his education?

And since this is the time for report cards and review, perhaps you should re-evaluate your own career. Are you as far along as a man of your ability should be? For example, are you earning as much as $12,490 a year? That was the 1956 average income of 562 representatives who have been with the Massachusetts Mutual Life Insurance Company five years or longer.

They are men like you — men chosen for their fine education and background. All received thorough training and earned while they learned. Now they are established in a career that uniquely combines independence with stable income—plus the security of group insurance and retirement benefits.

If you would like to know more about this opportunity, write for a free copy of "A Selling Career".

Massachusetts Mutual
LIFE INSURANCE COMPANY
SPRINGFIELD, MASSACHUSETTS
The Policyholders' Company

GAS STANDBY

Packaged 12 mcfh plant designed and built by Draketown for...

★ Utility or Industrial standby
★ Peak shaving and augmentation
★ 100% Town or plant supply

A Packaged Draketown Propane Plant will help you reduce demand charges; provide a supply of gas during curtailment periods... at the turn of a valve... or supply that outlying section or plant 100% if desired.

DRAKETOWN PROPANE PLANTS
"Good Gas Insurance"

If you have a gas problem, we can help you. We operate from coast to coast and overseas.
Phone or write today—no obligation.

DRAKE & TOWNSEND
Consulting • Design • Engineering • Construction
11 WEST 42ND STREET • NEW YORK 36, N. Y.

AT YOUR SERVICE

SPECIALIZED ENGINEERING
SPECIALIZED EXPERIENCE
SPECIALIZED MACHINERY
FOR
TWISTING · FORMING
STRANDING · BUNCHING
COTTON · JUTE · MANILA
SISAL · NYLON · DACRON
ORLON · SARAN · PAPER
POLYETHYLENE · GLASS

TEXTILE · WIRE · CORDAGE
and OTHER INDUSTRIES

HASKELL-DAWES
MACHINE CO., INC.
2231 E. Ontario Street
Philadelphia 34, Pa.

TOMORROW'S MANAGERS

(*Concluded from page 411*)

I shall add just three more comments and then I shall be done.

First, I am sure no one here has misunderstood me, but I want to make it crystal-clear that in urging wide-open paths to self-development, I am certainly not advocating greasing the ways for anyone. Quite the contrary. Really what I have been saying is that more men will do more growing as we give them the most opportunity to take the most exacting path. After all, it is harder to become everything you can be than it is to do anything else.

Second, I have not forgotten competition either: I mean the competition between people in any organization, the matching of brains against brains. We have always had this in American industry and the value is beyond calculation. Freedom to compete produces not only a better leader, but a better group for him to lead. It promotes competence through the whole organization, not just at the top. It constantly refreshes and renews the entire management stream.

But the great value is not alone in the fact of competition; it is even more in its quality. For example, we might get plenty of competition on the part of people trying to see who could conform most completely with all the rules and regulations, but that is not what we are after. Only as we succeed in giving men full and free opportunity to become their complete selves, are the benefits of competition fully realized.

Finally, our social institutions and all our history tell us that the right way to live and work and achieve is to give men real freedom to become all they can be. The approach I have been trying to express seems to me distinctively American. We have put fewer obstacles in the way of talent – obstacles of birth, of education, of money, of class – than other nations have. This country has grown great and our industry leads the world because here more than elsewhere we have acted on the conviction that everybody ought to have full opportunity to show what he can do.

This is our faith as Americans: faith in the process of human growth, which we only dimly understand, and cannot dictate. With this faith, we *will* continue to build and enlarge the kind of business climate that grows great men; and this achievement, I feel sure, will be our own deepest and most satisfying reward.

SCULLY SIGNAL COMPANY
Safe Fills / No Spills } with VENTALARM®
WHISTLING TANK FILL SIGNAL
for automotive, home and diesel fuel tanks

E. P. Scully '15 — 174 Green Street, Melrose 76, Mass.
"JUST FILL 'TIL THE WHISTLE STOPS"

the breakthrough

For the next big nuclear news, look to the field of applications engineering... And look into the Martin story!

For Martin research and development activities in nuclear applications – from air-transportable packaged power systems to fundamental exploration in the problems of nuclear engineering – are in the direction of the coming breakthroughs.

Contact J. J. Holley, Dept. N, The Martin Company, Baltimore 3, Maryland.

MARTIN
BALTIMORE

FREE BOOKLET TELLS WHAT CO_2 CAN DO FOR YOU

agriculture
chemistry
metals
electronics
refrigeration
food
drugs
textiles
rubber

There's practically no end to the important jobs that CO_2—combined with Liquid Carbonic savvy—is doing. Chances are this combination can come up with some surprising answers for you, too. For scores of CO_2 applications, covering all industry, send for LIQUID's new free booklet, "Applications Unlimited." Just use the coupon below.

MAIL THIS COUPON

THE LIQUID CARBONIC CORPORATION
3100 South Kedzie Ave., Chicago 23, Illinois TR

Send me my free copy of "Applications Unlimited."

Name_____

Company_____

Position_____

Address_____

City_____ Zone____ State_____

FINANCIAL FORCES IN INDUSTRIAL GROWTH

(*Continued from page 416*)

as the individual capital budget is a framework for the future of the individual company, the aggregate of such budgets is a framework for the future of the economy. Taken together, these decisions determine to a considerable extent the pace and process at which the productive capacity and standard of living of a nation will grow.

SEARCH FOR INVESTMENT OPPORTUNITIES

A company's long-range planning should include a creative search for investment opportunities and a flexible and understandable blueprint through which its growth potentials can be charted as an explicit guide to all concerned.

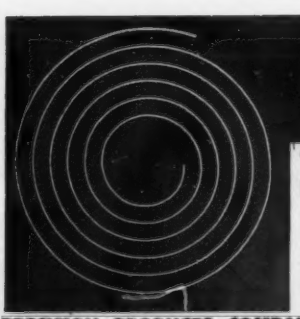
A plethora of good investment projects is essential to any capital investment program. The worst that can happen from too many good investment opportunities is that a company may not make some of these investments. On the other hand, a lack of good investment projects may lead to wasting money in low profitability projects. The same money can often be put to better use elsewhere; the problem is finding projects of higher profitability.

The most important factor in this search for new projects is good management. Since most new projects come from trying to find better ways of doing things, they come rather automatically in a managerial climate wth a fair amount of autonomy and freedom.

SEARCH FOR NEW PROJECTS

There also must be a conscious search for new projects. A major source is the research department, whose primary purpose is to discover new or improved products and methods; these in turn become the basis for new projects. Efforts of the industrial engineering team to find ways of reducing costs may turn up opportunities for projects with promise of high productivity. Economic analysis may yield insight to expanding areas and markets.

(*Concluded on page 438*)



"Precision-Gauged"
HAIRSPRINGS
More than 20 years' experience making all types of hairsprings for critical instrument applications. High volume production with absolute uniformity.

PRECISION PRODUCTS COMPANY INC OF WALTHAM
WALTHAM 54 • • MASSACHUSETTS

ENGINEERS

get in on the military electronic advances

TODAY

that pave the way for commercial developments

TOMORROW

at the Otis Electronic Division

The full resources of the century-old Otis Elevator Company are available for expansion of its new Electronic Division. And engineers who join this division now will have the satisfaction of working in the forefront of the military electronics field . . . with the realization that its potentialities in commercial development will also be explored by Otis . . . that this is a long-range program in which Otis will spare no effort in broadening the position of its Electronic Division as a leader in this important field of industry.

Current prime contracts are on basic development work in the most advanced areas of bombing navigation systems, radar systems and missile launching test equipment.

Engineering know-how is required in servo-mechanisms, analog computers, pulse and sweep generators and in the field of microwaves.

If you are interested in a high level career in electronics . . . with promotions waiting to be earned . . . send your resume now to William B. DeFrancis. All inquiries in strict confidence.

ELECTRONIC DIVISION

OTIS ELEVATOR COMPANY

35 Ryerson Street, Brooklyn 5, N. Y.

FINANCIAL FORCES IN INDUSTRIAL GROWTH

(*Concluded from page 436*)

The first step, then, in a good capital budgeting program is to create an organization that will build up an abundance of high return investment possibilities. A subsequent step is to embody ideas produced by such an organization into an understandable and defensible long-range plan.

Long-range planning is important in any modern system because capital projects commit a company to the distant future. Not only do capital projects have a long gestation period, but they also have a long period of life. Secondly, individual capital projects must be fitted in a company's development of its people. Long-range planning helps overcome imbalance or bottlenecks in production or distribution that arise from haphazard programming. It also forces an explicit estimate of how management views the future.

Fortunately, in a growing economy long-run mistakes are covered by absolute growth. But even though the economy may continue to grow, capital budgeting should not be done in a careless fashion.

The short-range annual capital budget should serve as a central clearing mechanism for allocating funds among competing uses. In order to achieve optimum results, there is need for a clear-cut procedure for submitting, processing and auditing capital expenditure proposals.

Departmental estimates made in connection with individual appropriation requests should be understandable and defensible. Similarly, decisions made in the central capital budget should be understandable and defensible ones. For accepted proposals, actual project outlays and benefits should be compared on a periodic basis against original estimates. Such a postmortem on authorized outlays is necessary in order to keep departmental estimates realistic. It also provides a basis on which techniques for projecting sales, costs and margins might eventually be assayed and improved.

Summary

By way of summary, I do not believe that private capital formation necessary to maintain the long-term average annual rate of increase in per capita real income will be inhibited by a shortage of funds over the next decade. The terms of financing, however, will be more restrictive in the years ahead than was true of the postwar period. It is obvious that efficiency always provides an advantage. What I am trying to say is that the extent of this differential advantage is going to increase markedly in the future. Thus the business firms with more efficient financial management will enjoy greater advantages over their competitors in the future than has been true for the last 25 years.

SPECIAL REPORT

Mr. CHARLES E. SEIM — NEW YORK LIFE AGENT

at SPOKANE, WASHINGTON

BORN: Oct. 13, 1928.

EDUCATION: Washington State College, A.B., June, 1952

MILITARY: U. S. Army Engineers—Sgt., Sept. '46—March '48

PREVIOUS EMPLOYMENT: August '42 to June '44—Clothing Salesman. Summers of '48, '49, '50, '51—Part-time building construction work.

REMARKS: Each year since June, 1952, when he first joined New York Life's Spokane office, immediately following his graduation from college, Charles Seim has achieved membership in either the Company's Star Club or its Top Club—recognition of his outstanding sales performance. Last year he sold more than $1,000,000 of life insurance protection. Important factors in compiling this remarkable record are Mr. Seim's personality, his industry and his intense interest in his clients' insurance problems. Only 29 years old now and consistently a sales leader, Charles Seim seems certain to go on to even greater success with New York Life in the years to come.

Note

Charles E. Seim, after five years as a New York Life representative, is already well established in a career that can offer security, substantial income, and the deep satisfaction of helping others. If you'd like to know more about such a career for yourself with one of the world's leading life insurance companies, write:

NEW YORK LIFE INSURANCE CO.
College Relations Dept. B-26,
51 Madison Avenue, New York 10, N.Y.

Here's how Haspel makes you comfortable even in the hottest summer weather . . . .

Sir Perior Suits and Jackets

(75% DACRON 25% COTTON)

an exclusive Selfcaire fashion

No other suit boasts so many advantages! The smart fashion that gives you such a distinguished appearance lasts and lasts . . . through the most wilting weather, carrying you in crisp, cool comfort . . . through innumerable launderings, with no special care required. You simply suds, rinse and drip-dry on a wooden hanger. It "irons" itself . . . is impeccably ready to go the next morning.

SUITS 39.75
JACKETS 28.50

Prado Cord Suits and Jackets

Here is the suit that has become a summer tradition with the well-dressed men everywhere. The reasons are many. One is that the cool, crisp cotton fabric, specially treated for wrinkle-resistance, is wonderfully comfortable on hot days. Another is the incomparable HASPEL taste, talent and technique. And, of course, the smart styling of Prado Cord gives every man a slimmer, more flattering appearance. And, of course, it's washable.

SUITS 28.75
JACKETS 20.50

Join — Buy
Save
8% or 10%

THE COOP
Harvard Square

LIFE SCIENCES

(*Concluded from page 426*)

to the study of proteins and the mechanism whereby protein molecules aggregate and associate under certain conditions. Special attention is being devoted to the formation of fibrils from the aggregation of corpuscular insulin molecules, and, in addition, the mechanisms of blood and milk coagulation are being investigated by physical chemical methods. These laboratory studies on amino acids and proteins should yield information concerning their role in living organisms.

In the field of embryology, focused ultrasound is being used as a surgeon's scalpel at the cellular level to determine the role of various cells and tissues in embryonic development. These same techniques of focused ultrasound make possible the localization of malignant tumors in the human body.

In the biological Instrumentation Laboratory, research is centered on the development of electrical instruments for use in biology and medicine. At the present time, special attention is being given to the development of a sensitive two-dimensional parallel plane Geiger counter with a photographic film to be used primarily for the detection of x-rays.

The Biology Department, in addition to its research program, provides a major center for training of students in the biological sciences. Both graduate, undergraduate, and postdoctoral students are trained in the techniques of research with the result that the majority of students who receive degrees in biology undertake research careers in medicine, in academic institutions, or in industrial and government laboratories.

In view of the large number of research projects in the life sciences scattered throughout the Institute, the question arises as to the mechanisms whereby these programs are integrated and correlated. In the last few years they have evolved almost spontaneously in many different areas, as unique facilities in the physical sciences and engineering became available for the solution of biological problems. Since these studies have evolved quite independently there has been relatively little correlation of projects in the life sciences in one department with those in another. There is no thought, at the present time, of bringing all of the research in the life sciences under one central organization. On the other hand, M.I.T. is interested in encouraging in every way the growth of research in this area and is anxious to have a particular research project in one department not develop in isolation, but rather to benefit from contacts with research workers in other departments who are interested in related problems. Different ways of implementing the co-ordination of the life sciences are being investigated, and, in particular, joint seminars are being set up and informal discussions arranged for the better co-ordination of research in related areas. There can be no doubt that all the various projects at M.I.T. will benefit from this cross-fertilization of ideas among the many research groups, and that investigations in the life sciences will develop at an accelerated pace as a result.

Pattern of Research in Life Sciences

In an examination of the 117 research projects in the life sciences at M.I.T., one is most impressed by their diversity, and wonders if there is any basic pattern of research in this area. Certainly many aspects of the life sciences are not covered. Fields such as botany, agriculture, morphology, anatomy, ecology, and many other types of biology stressed in other institutions are not represented here. The pattern of research in the life sciences shows a strong influence of the basic sciences, particularly mathematics, physics, and chemistry, as well as the fields of engineering, on the type of investigation going on at M.I.T. Just 20 years ago there was organized a new field called Biological Engineering by three progressive and far-sighted scientists: the late Karl T. Compton, formerly President of the Institute; John W. M. Bunker, Dean of the Graduate School, Emeritus; and Vannevar Bush, '16, Chairman of the M.I.T. Corporation. In developing this new type of biology it was their intention to see the application of science and engineering to teaching and research in the life sciences. It is just this type of biology which has developed throughout the Institute over a score of years and it seems to ideally set the pattern for research in the life sciences for years to come. It is not too optimistic to expect that M.I.T. will become one of the major centers in the world for research in the life sciences as a result of the application of this concept over the next decade or so.

William H. Coburn & Co.
INVESTMENT COUNSEL
68 Devonshire Street
Boston

George M. Wolfe '40
A. J. WOLFE CO.
Electrical Construction
SINCE 1924
2 HARRIS AVE. JAMAICA PLAIN 30, MASS.

The TREDENNICK-BILLINGS CO.

Construction Managers — *Building Construction*

K. W. RICHARDS '07 · H. D. BILLINGS '10 · C. C. JONES '12 · F. J. CONTI '34

10 HIGH STREET — BOSTON, MASSACHUSETTS

JUST PUBLISHED

NEW • ENLARGED • REVISED

EDITIONS OF

Smoley's Tables

350 New Pages

Time Savers for Designers & Builders since 1901. Check items of interest to you:

- ☐ Logs and Squares, Parallel Tables increased 100′ to 300′ — $ 6.00
- ☐ Slopes & Rises (Tables doubled) 192 bevel pages increased to 384 — 6.00
- ☐ Log. Trig. Tables areas and circumferences extended — 1.50
- ☐ Three Combined Tables — 10.00
- ☐ Four Combined Tables — 12.00

Mail Orders & Inquiries to:

C. K. Smoley & Sons, Inc.

P.O. Box 14, Chautauqua, N. Y.

Recent books from

THE TECHNOLOGY PRESS

★★★★★★★★★★★★★★★

SCIENCE AND ECONOMIC DEVELOPMENT:

New Patterns of Living

by Richard L. Meier $6.00

". . . a conscientious effort to find what the new developments in the physical sciences require by way of new social expression, and to measure both needs and the resources to meet them."

— American Academy of Political and Social Science

"Meier's tentative solution — or hope — is a new species of human kind, whom he sees coming to the rescue: The scientist-executive."

— *Newsweek*

★★★★★★★★★★★★★★★

LOCATION AND SPACE-ECONOMY

A General Theory Relating to Industrial Location, Market Areas, Land Use, Trade and Urban Structure

by Walter Isard $8.75

". . . a landmark in locational theory." — Urban Land Institute

★★★★★★★★★★★★★★★

Published jointly with John Wiley & Sons, Inc.

ORDER FROM YOUR BOOKSELLER

BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865

Boit, Dalton & Church

INSURANCE SINCE 1865

89 BROAD STREET, BOSTON 10 • *Telephone* HUbbard 2-3100

FREDERIC C. CHURCH · CHAS. COLBY HEWITT
COLLINS GRAHAM · STANLEY H. KING · FRANK W. HUMPHREY
MYRON E. WATSON · ROBERT W. HARDING

BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865 · BDC 1865

ENGINEERS
HN
CONSTRUCTORS

HOLMES & NARVER, INC.

ENGINEERS • CONSTRUCTORS

JAMES T. HOLMES
M.I.T. '24
D. LEE NARVER
STANFORD '24

828 S. Figueroa St., Los Angeles 17, California
Telephone TRinity 8201

SYSKA & HENNESSY, INC.

Engineers

John F. Hennessy '24 — John F. Hennessy, Jr. '51

S H

DESIGN • CONSULTATION • REPORTS
POWER PLANT • WASTE DISPOSAL • WATER SYSTEMS
New York City

CHAUNCY HALL SCHOOL

Founded 1828. The School that specializes in the preparation of students for the Massachusetts Institute of Technology.

Ray D. Farnsworth, *Principal* 533 Boylston Street, *Boston, Mass.*

LEONARD CONSTRUCTION COMPANY

Engineers and Contractors

SINCE 1905

IN THE AMERICAS AND FAR EAST
37 South Wabash Ave.
Chicago

R/L

ROTH LABORATORY
FOR PHYSICAL RESEARCH

Serving Industry in these fields —

ELECTRONICS — MATHEMATICAL ANALYSIS
AUTOMATION — RESEARCH MANAGEMENT
MEDICAL PHYSICS — ANALOG COMPUTERS
ULTRASONICS — INSTRUMENTATION

1240 MAIN STREET • JAckson 7-8211
HARTFORD 3, CONNECTICUT

Wilfred Roth
M.I.T. '48
Columbia '43

INDUSTRIAL MANAGEMENT CONVOCATION

(Concluded from page 408)

Management is gradually becoming a profession, Dr. Bush held, with all that that term connotes. Directors need not abandon the interests of stockholders, but they need to widen their horizons so that this is not the only view they see.

Evening Session

The day's activities were concluded with a social hour and banquet at the Hotel Sheraton Plaza in Boston. James R. Killian, Jr., '26, as M.I.T. President, presided, and Alfred P. Sloan, Jr., '95, Honorary Chairman of the Board of General Motors Corporation, was guest of honor. The Reverend Theodore P. Ferris, Rector of Trinity Church, Boston, and a member of the M.I.T. Corporation, gave the invocation. Cleo F. Craig, Chairman of the Board, American Telephone and Telegraph Company, made the principal address, "Tomorrow's Managers."

Following the dinner, Dr. Killian spoke on the history and significance of the School of Industrial Management. He remarked that while some may have had some doubt about the School of Industrial Management at the time of its founding, "now, five years later, we look with parental pride and enthusiasm at our newest school." Mr. Sloan not only provided the funds which made the new school possible, said Dr. Killian, but "he has set for it a standard of performance and a vision of greatness. He has brought wise and creative thinking to our councils; he stands as a towering example to our Faculty and students. We salute him for what he has done and for this school, for M.I.T. and for his country."

To the introduction given by Dr. Killian, Mr. Sloan responded by stating his view that the convocation of April 9 marked a milestone in the evolution of the School of Industrial Management in which it had been a privilege to participate. Mr. Sloan remarked that "we have reached or already surpassed the goals Dr. Compton and I foresaw for the School." This has been possible, he said, because of the brilliant leadership provided by Dr. Killian and Dean Brooks, and the generous contributions of many industrial leaders who served as able advisers in the development of the School's curriculum. "I have found," said Mr. Sloan, "the discipline of science and engineering of immense value as chief executive officer of the General Motors Corporation. The industrial leaders of the future will be still more certain of the value of the technological background for management. It is M.I.T.'s responsibility to be a leader in the developments such as this."

The last event of the day's program was the address by Mr. Craig, "Tomorrow's Managers," which the reader will find reproduced on page 409.

By 9:30 P.M., the convocation was over. Those who were fortunate enough to attend the day's events may have taken back to their homes a new conception of modern methods of training managers for the industrial society of tomorrow. But all shared in the hopes and aspirations of a great educator and of a great industrialist — Karl T. Compton and Alfred P. Sloan, Jr., '95.

PROFESSIONAL CARDS

JACKSON & MORELAND, INC.

Engineers and Consultants

DESIGN AND SUPERVISION OF CONSTRUCTION

REPORTS—EXAMINATIONS—APPRAISALS

MACHINE DESIGN—TECHNICAL PUBLICATIONS

BOSTON NEW YORK

GANNETT FLEMING CORDDRY AND CARPENTER, INC.

Engineers

HARRISBURG, PA.

Branch Offices:

Pittsburgh, Pa. Daytona Beach, Fla. Philadelphia, Pa.

Expressways, Toll Roads, Bridges and Airports. Traffic & Parking. Dams, Water Works, Sewage, Industrial Wastes and Garbage Disposal. Appraisals, Investigations and Reports.

EADIE, FREUND AND CAMPBELL

CONSULTING ENGINEERS

500 FIFTH AVENUE NEW YORK 36, N. Y.

Mechanical—Electrical—Sanitary

Air Conditioning—Power—Process Layouts

J. K. Campbell, M.I.T. '11

METCALF & EDDY

Engineers

Water, Sewage, Drainage, Refuse and Industrial Wastes Problems

Airports, Laboratory, Valuations

Statler Building, Boston 16, Mass.

THE KULJIAN CORPORATION

Consultants • Engineers • Constructors

UTILITY • INDUSTRIAL • CHEMICAL

Power Plants (Steam, Hydro, Diesel), Textile Plants, Water & Sewage Works, Oil Refineries, Pipe Lines, Army & Navy Installations, Air Fields, Hangars

H. A. Kuljian '19 A. H. Kuljian '48

1200 NO. BROAD ST., PHILADELPHIA 21, PA.

FABRIC RESEARCH LABORATORIES

Incorporated

Research, Development and Consultation for Textile and Allied Industries

1000 Providence Highway Dedham, Mass.

W. J. HAMBURGER, '21 K. R. FOX, '40 E. R. KASWELL, '39

GILBERT ASSOCIATES, INC.

ENGINEERS AND CONSULTANTS

607 WASHINGTON ST., READING, PA.

Malcolm G. Davis '25, *Vice President* Allen W. Reid '12, E. C. Edgar '25

Steam, Hydro, Diesel Power Plants; Industrial Structures; Plant Safety, Labor Relations, Utility Rates, Valuations, Reports; Large Scale Purchasing; Industrial Laboratory

New York • Washington

FAY, SPOFFORD & THORNDIKE, INC.

Engineers

Airports, Bridges, Turnpikes

Water Supply, Sewerage and Drainage

Port and Terminal Works, Industrial Buildings

Designs Investigations

Supervision of Construction

Boston, Massachusetts

CLEVERDON, VARNEY & PIKE

Consulting Engineers

HERBERT S. CLEVERDON '10 WALDO F. PIKE '15

JOHN A. DOW '23 HAROLD E. PROCTOR '17

Structural Designs Foundations

Heating, Ventilating, Electric and Plumbing Designs, Industrial Buildings, Reports, Investigations

120 TREMONT STREET BOSTON 8, MASS.

MAURICE A. REIDY

Consulting Engineer

BRIDGES BUILDINGS

STRUCTURAL DESIGNS FOUNDATIONS

CONSTRUCTION CONSULTANT AND ARCHITECTURAL ENGINEER

Estimates and Appraisals

101 TREMONT STREET BOSTON, MASS.

CHARLES NELSON DEBES AND ASSOCIATES

ENGINEERS AND CONSULTANTS

Architectural — Mechanical — Electrical — Structural

Management — Plant Layout — Material Handling

Acoustical

915 EAST STATE ST. ROCKFORD, ILL.

C. N. DEBES '35 R. S. KNOWLAND '40

MORAN, PROCTOR, MUESER & RUTLEDGE

CONSULTING ENGINEERS

Foundations for Buildings, Bridges and Dams; Tunnels, Bulkheads, Marine Structures, Soil Studies and Tests; Reports, Design and Supervision

WILLIAM H. MUESER '22 PHILIP C. RUTLEDGE '33

415 Madison Ave., New York 17, N. Y.

GIVEN BREWER

Consulting Engineer

Electric Strain Gage Testing • Stress Analysis

Strain Gage Amplifiers • Strain Gage Switches

MARION, MASS. TEL. 103, 110

G. A. Brewer '38

CAPITOL ENGINEERING CORPORATION

CONSULTING ENGINEERS

Design and Surveys

Roads and Streets

Sewer Systems Water Works

Planning Airports

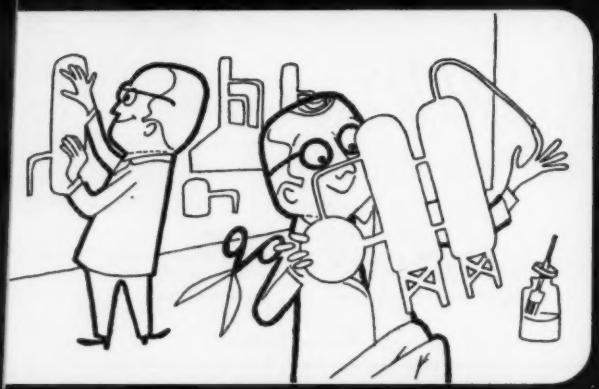
Bridges • Turnpikes • Dams

Executive Offices

DILLSBURG, PENNSYLVANIA

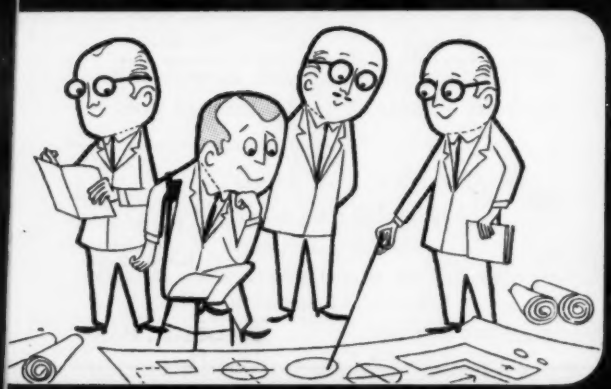
Dallas, Texas Rochester, N. Y.

Robert E. Smith '41, Vice President

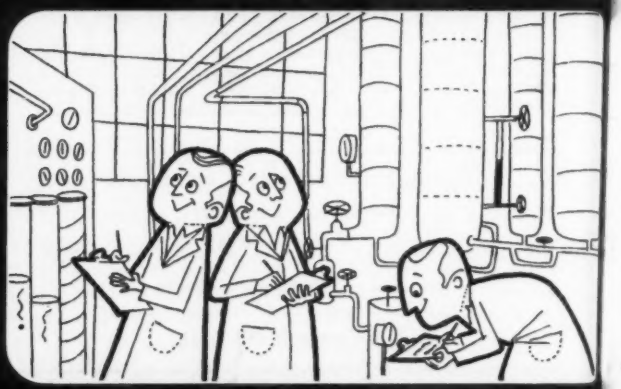


fore Lummus submits a proposal to design and construct your new plant, skilled engineers first build it on paper.

They are helped by a global fact-finding network alert for new developments.



Teamwork converts this knowledge into the best design for *your* requirements.



Laboratory and Pilot Plant Groups prove out the soundness of new ideas.

Now Lummus can tell you how much your new plant will cost and how effectively it will produce.

All the facts go into the proposal—which is put on your desk as a complete plan for your new facility.

How Lummus proposes to build your new plant

Into a typical Lummus proposal go hundreds of man-hours by scores of specialists. No detail that will affect cost or operating efficiency is omitted. That's why a Lummus proposal is much more than a sheaf of blueprints and a price tag; it's a comprehensive plan for assisting you to increase your production and profits.

If you're thinking of a new chemical facility, petroleum refinery or other type of process plant, it will pay you to discuss your plans with Lummus.

THE LUMMUS COMPANY
385 Madison Avenue, New York 17, N. Y.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

HOUSTON • CHICAGO • MONTREAL • CARACAS • LONDON • PARIS • THE HAGUE • BOMBAY

Wire sculpture by Henry Szafarz

The Inside Story

Beneath the surface, there's a lot going on.

An underground river of power surges through innumerable cables, supplying the electrical energy that keeps the entire community rolling smoothly.

Throughout the nation, Simplex products are used extensively in such applications. This is particularly true of ANHYDREX XX, the ideal all-purpose cable for high-voltage use. This expertly engineered cable is popularly employed in the 2001 to 35,000 volt range, and has a Conductor Temperature Rating of 90°C up to 5 KV (a rating never attained before the development of ANHYDREX XX).

For more technical data, write for Booklet 1023.

SIMPLEX WIRE & CABLE CO., 79 Sidney Street, Cambridge 39, Mass.

Simplex Anhydrex XX Underground Cable

Simplex

LIVE BETTER ELECTRICALLY

Strobotac® *Checks Speed Torque Characteristics of VARD Magnetic Clutch*

Strobotac makes it possible to see rapidly moving parts and mechanisms as though they were operating in s-l-o-w motion or actually standing still. The instrument operates from usual 105 to 125v, 60c lines . . . is 7⅝ x 9 x 10 inches . . . weighs less than 10 pounds.

Range: Direct reading 600 to 14,400 rpm
Useful 60 to 100,000 rpm.

Flash Duration: 10 to 40 microseconds.

Accuracy: ±1% of scale
Built-in calibration system.

Type 631-BL Strobotac.....$160

Developed for auto-pilots and countless other servomechanism applications, the Vard clutch depends for its operation on a magnetically induced torque accomplished in much the same manner as in an induction motor. It is controlled by variable d-c excitation which requires about five-percent of the power being transmitted at any nominal speed — thus actuator gearbox outputs are readily regulated for almost any need.

Vard uses the Strobotac to check rotational speed accurately, and to establish steady-state, speed-torque characteristics. From this data the effects of other clutch constants — cage resistance, reactance and the like — can be anticipated and controlled.

Strobotac measures the speed of rotating, reciprocating, or other cyclic motions with accuracy. The operator can "stop" the moving part completely — study it in slow motion — or measure its rpm while it is running at full speed. There is no mechanical connection to induce even a slight "drag" in low-powered mechanisms.

All over the world, Strobotac helps solve research and design problems. This "laboratory" instrument is also a prime industrial tool for maintaining production, quality control, and diagnosing all kinds of mechanical troubles.

Write for the **STROBOSCOPE BULLETIN** and complete information

GR® General Radio Company

275 Massachusetts Avenue, Cambridge 39, Mass., U.S.A.

Broad Avenue at Linden, Ridgefield, N. J. **NEW YORK AREA**
8055 13th St., Silver Spring, Md. **WASHINGTON, D. C.**
1182 Los Altos Ave., Los Altos, California **SAN FRANCISCO**
1000 N. Seward St. **LOS ANGELES 38**
1150 York Road, Abington, Pa. **PHILADELPHIA**
6605 W. North Ave., Oak Park **CHICAGO**